Aeroplane Maintenance and Operation Series. Volume 9

ENGINES

(PART 2)

AEROPLANE MAINTENANCE AND OPERATION SERIES

Compiled under the General Editorship of E. MOLLOY

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Aeroplane Maintenance and Operation Series, Volume 9

ENGINES

(PART 2)

DEALING WITH THE MAINTENANCE AND REPAIR OF THE DE HAVILLAND GIPSY "TWELVE," GIPSY "MAJOR SERIES II," AND GIPSY "TWO" AND "THREE" ENGINES

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COMPILED BY A PANEL OF EXPERTS

WITH FIFTY-SEVEN ILLUSTRATIONS

GEORGE NEWNES LIMITED

Tower House, Southampton Street, Strand

LONDON, W.C.2

PREFACE

THE well-known de Havilland range of " Gipsy " engines are probably as familiar to all aircraft engineers as the " Morris " engines are to the motor-car engineer. They are good examples of sound, modern practice in aero-engine design and are widely used on a large number of aeroplanes.

The three examples of the " Gipsy " range which form the subject matter of the present volume are the Gipsy " Twelve," the Gipsy " Major Series II." and the Gipsy " Two " and " Three " engines.

The Gipsy " Twelve " is an outstanding example of a modern twelve-cylinder, inverted " V," in-line, air-cooled, geared and supercharged engine, with an international rating of 405/420 B.H.P. at 2,400 r.p.m. at 7,500 ft. zero boost. It was designed by Major F. B. Halford. A noteworthy feature of this engine is its low frontal area and low cooling loss.

Under the system of nomenclature of the British Air Ministry the name " Gipsyking I " is applied to this engine when equipped with auxiliaries to the Air Ministry specification.

The Gipsy " Major Series II " is a four-cylinder, inverted, air-cooled, in-line engine, with an international rating of 132/138 B.H.P. The Gipsy " Two " and " Three " are also four-cylinder, air-cooled, in-line engines, the " Two " being vertical and the " Three " inverted, both developing 108/110 B.H.P. at normal r.p.m.

Each section begins by describing briefly the leading features of the engine under discussion, and this is followed by instructions for dismantling, detailed inspection of component parts, and reassembling. Details are also given of the recommended maintenance schedule.

Wherever possible action photographs have been included to amplify the instructions given in the text, and we believe that readers will appreciate the advantages of these illustrations.

We are especially indebted to the de Havilland Aircraft Co., Ltd., for their invaluable assistance, which has made the compilation of this volume possible.

In conclusion, we would say that this book is offered to the ground engineer and air mechanic in the firm belief that it will be found invaluable whenever any practical difficulty has to be overcome in connection with these famous engines selected from the "Gipsy" range.

E. W. K.
E. M.

CONTENTS

ENGINES

THE "GIPSY TWELVE" ENGINE

NOTES ON DISMANTLING, INSPECTION, REASSEMBLY, AND MAINTENANCE

THE "Gipsy Twelve" engine is a twelve-cylinder, inverted "V," in line, air-cooled, geared, and supercharged engine designed by Major F. B. Halford, and manufactured by the de Havilland Aircraft Co., Ltd.

This engine is noteworthy on account of its low frontal area and low cooling loss, and lends itself to a cowling of circular cross section. Under the system of nomenclature of the British Air Ministry, the name "Gipsyking I" is applied to the "Gipsy Twelve" engine when equipped with auxiliaries to the Air Ministry specification. The "Gipsy Twelve" and "Gipsyking I" are thus identical, except for auxiliaries and minor external features.

Alternative Combinations of Auxiliaries

Alternative combinations of auxiliaries are as follows: on the front of the engine either a vacuum pump (for navigation instruments) or an oil pump (for automatic pilot and for hydraulic jacks to control cooling gills) may be fitted. On the rear of the engine (*a*) generator drive only, or (*b*) generator drive and high-power hydraulic pump (for undercarriage or gun-turret operation), or (*c*) hydraulic pump only, or (*d*) air compressor only (for wheel brakes, etc.).

Alternative gearboxes are supplied to provide the different shaft speeds required for individual auxiliaries.

In order to familiarise the reader to some extent with the engine to be dealt with in the following pages, the leading particulars are given in tabular form.

This is followed by a detailed description of the components, instructions for dismantling, detailed inspection of the component parts, and reassembly (including valve timing and magneto timing). The section concludes with a recommended maintenance schedule for the "Gipsy Twelve" engine under service conditions.

LEADING PARTICULARS OF "GIPSY TWELVE"

Type:	Twelve cylinder, inverted Vee, air cooled, geared, and supercharged.
Numbering of cylinders:	1, 2, 3, 4, 5, 6, "A," R.H.
(Reading from airscrew end as No. 1 for each bank.)	1, 2, 3, 4, 5, 6, "B," L.H.
Firing Order:	1A, 6B, 5A, 2B, 3A, 4B, 6A, 1B, 2A, 5B, 4A, 3B.
Bore:	118 mm. (4·646 in.)
Stroke:	140 mm. (5·512 in.)
Swept volume:	18·372 litres (1121·2 cu. in.)
Compression ratio:	6 to 1.
Reduction gear ratio:	·667 to 1.
Supercharger crank-shaft gear ratio:	7·14 to 1.
Direction of rotation of airscrew:	Left-hand tractor.

Performance

International rating:	405 420 B.H.P. at 2,400 r.p.m. at 7,500 ft. zero boost.
Maximum power rating:	410 425 B.H.P. at 2,450 r.p.m. at 7,750 ft. zero boost.
Maximum take-off power:	505 525 B.H.P. at 2,600 r.p.m. at sea-level.

Limiting Conditions

Take-off at maximum r.p.m.:	2,600 r.p.m. at plus 3½ lb. sq. in. boost pressure.
Take-off at minimum r.p.m.:	2,400 r.p.m. plus 3½ lb. sq. in. boost pressure.
Maximum climbing:	2,400 r.p.m. at zero boost pressure.
All-out level flight (5 mins.):	2,450 r.p.m. at zero boost pressure.
Maximum for continuous cruising:	2,200 r.p.m. at minus ¾ lb./sq. in. boost pressure.
Maximum for economical cruising:	2,200 r.p.m. at minus 2 lb./sq. in. boost pressure.
T.V. diving r.p.m. (at less than ⅓ throttle):	2,600 r.p.m.
T.V. diving (at not more than zero boost):	2,600 r.p.m.

Powers at Sea Level

Take-off at maximum r.p.m.:	505 525 B.H.P., 2,600 r.p.m., plus 3½ lb./sq. in. boost.
Take-off at minimum r.p.m.:	510 B.H.P., 2,400 r.p.m., plus 3½ lb./sq. in. boost.
Maximum climbing:	390 B.H.P., 2,400 r.p.m. zero boost.
All-out level flight (5 mins.):	395 B.H.P., 2,450 r.p.m. zero boost.
Maximum for continuous cruising:	345 B.H.P., 2,200 r.p.m., minus ¾ lb./sq. in. boost.
Maximum for economical cruising:	* 305 B.H.P., 2,200 r.p.m., minus 2 lb./sq. in. boost.

Consumption—Fuel

Full specification: D.T.D. 230

Cruising: at maximum cruising conditions at 7,500 ft.: 375 B.H.P., 2,200 r.p.m., 27/29 galls./hour (·58/·63 pints/B.H.P./hour).

* This power is at maximum power mixture strength: a power drop of 3 per cent. to 4 per cent. is experienced with economical cruising mixture strength.

At maximum economical cruising conditions at 10,000 ft.: 330 B.H.P., 2,200 r.p.m., 20·21 galls. hour (·49·51 pints B.H.P. hour).
At maximum take-off conditions at sea level: 44·47 galls. hour.
At maximum climbing conditions at sea level: 30·32 galls. hour.
At maximum power level flight: 32·35 galls. hour.
Min. max. fuel pressure: ½ 2½ lb. sq. in.

Oil

Oil specification:	D.T.D. 109.
Oil consumption:	6 to 14 pints hour.

Oil Inlet Temperatures

Maximum for cruising:	70° C.
Maximum for climbing:	80° C.
Maximum for all-out level flight (5 mins.):	90° C.
Minimum for opening up after cold starting:	25° C.

Ignition

Timing:	Interconnected with airscrew governor 34° maximum advance.
Contact-breaker gap (contact breaker full advance):	·011 in. to ·013 in.
Sparking-plug gap:	·012 in. to ·015 in.

Valve Timing

Inlet-valve tappet clearance (cold):	·005 in.
Exhaust-valve tappet clearance (cold):	·005 in.
Inlet valve opens:	32¾° before O.D.C.*
Inlet valve closes:	82¾° after I.D.C. †
Exhaust valve opens:	79¼° before I.D.C.
Exhaust valve closes:	36¼° after O.D.C.
Net dry weight of engine:	1,058 lb.

The engine drives a de Havilland airscrew, type 4,000, operating in conjunction with a constant-speed governor.

"Top Dead Centre," now referred to as "Outer Dead Centre," refers to the position of the piston when it is at the beginning of either the power or the induction stroke as the case may be. "Bottom Dead Centre" is referred to as "Inner Dead Centre."

Equipment of a Standard "Gipsy Twelve" Engine

Oil Pumps:	1 pressure and 2 scavenge for main lubrication. 1 metering pump for supercharger lubrication.
Oil Filters:	3 scavenge and 2 pressure (1 Auto Klean and 1 Tecalemit).
Ignition:	2 B.T.H. magnetos, Type C.2, S.E. 12S, in conjunction with Breeze Harness and integrally screened plugs.
Starter:	B.T.H. starter motor, Type 3750, Form F.F.2, in conjunction with B.T.H. Booster Coil, Type C.T.S. 24 volt.
Doping:	Ki-gas doping connections fitted in induction pipe and supercharger.

* O.D.C. = Outer Dead Centre. † I.D.C. = Inner Dead Centre.

Carburettor	S.U. Type A.V.F. 25 incorporating automatic boost and mixture controls.
Accessory Gearbox	De Havilland type B.X.S.
Controls	Arranged for "Exactor" type control. The three control units operate on throttle only, (1) magneto and airscrew governor, and (2) four-position mixture lever.
Air Intakes	Combined hot and cold carburettor air intake fitted.

Optional Accessory Equipment

Constant-speed airscrew and spinner.
Vacuum pump, Rotax B. 2A, or Northern oil pump.
Controls arranged with lever pick-ups for rod operation.
Thermo couple, Weston type H.
Drive box and flexible drive for 500 watt, 12- or 24-volt generator.
Drive box and flexible drive for generator and hydraulic pump.
Drive box for hydraulic pump only.
Dowty hydraulic pump, Type 3589.
Drive and B.T.H. air compressor, Type A.V.A.
Rubber sleeves and retaining rings on tappet-rod casing tubes (for engines operating in salted lodia atmospheres).
Fuel pumps: Amal type 190 A.E. 3.
Hydraulic ram for cooling flap operation.

DETAILED COMPONENT DESCRIPTION

Cylinder Head

This is an aluminium alloy casting, which is held to the cylinder barrel by four high tensile steel studs screwed at their upper ends to the crankcase. The joint between the head and the cylinder is made by a copper-asbestos washer which fits into a recess in the cylinder head. Flanged bronze guides are fitted for one inlet and one exhaust valve, the high-expansion steel seatings being shrunk and peened into position in the cylinder head. Dual ignition is provided with two 14-mm. sparking plugs fitted one in each side of the cylinder head. The cylinder heads are provided with liberal fin area to ensure adequate cooling.

Cylinder

The cylinder is a carbon steel forging machined externally to form cooling fins and ground internally. Special attention is paid to the graduation of wall thickness and depth of finning in order that distortion may be avoided and an even cooling effect obtained. It is afterwards specially treated for protection against corrosion. The cylinder barrel is spigoted into the cylinder head, the joint being made by an intervening copper-asbestos washer. The other end of the barrel fits into the crankcase to the extent of the flange on the barrel, an oiltight joint being formed by compressing a Dermatine ring between the radius of the flange and the chamfered edge of the crankcase bore.

THE "GIPSY TWELVE" ENGINE

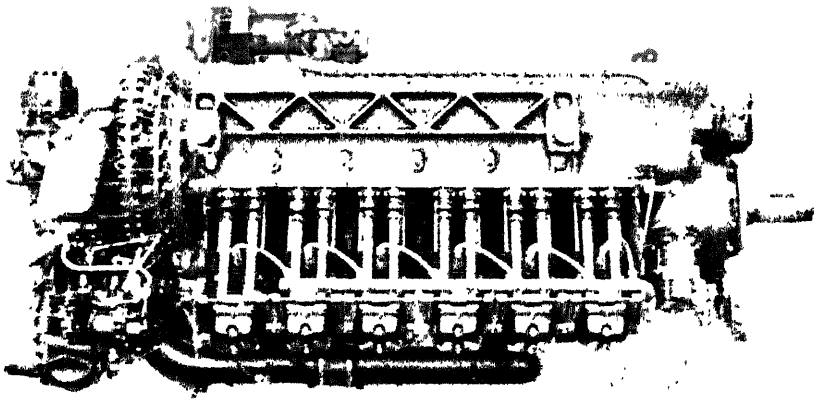

Fig. 1.—THE "GIPSY TWELVE" ENGINE

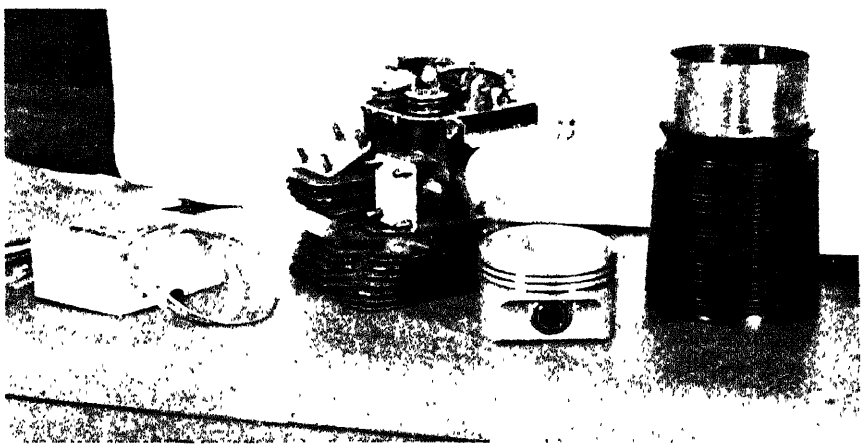

Fig. 2.—PISTON RINGS, CYLINDER-HEAD ASSEMBLY, PISTON, AND CYLINDER

Three rings are fitted to each piston, the inner ring being of the scraper type. The cylinder head is an aluminium alloy casting, which is held to the cylinder barrel by four tensile steel studs screwed at their upper ends to the crankcase. The piston is of the slipper type, and is machined from an upset forging of aluminium alloy. The cylinder is a carbon-steel forging machined externally to form cooling fins, and ground internally.

Piston

This is machined from an upset forging of aluminium alloy, and is of the slipper type, so designed that the stress from the crown is taken direct to the gudgeon pin, which floats in both the piston and the small end of the connecting rod and is retained by external circlips and washers at each end. Three rings are fitted to each piston; the inner ring is of the scraper type which scrapes oil from the cylinder wall, and deflects it through a series of small drilled holes to the inside of the piston and so back to the crankcase.

Connecting Rods

The " H " section connecting rods are machined all over from forgings of 65-ton nickel chrome steel. The master rod is forked at its big end to receive the plain connecting rod. Both rods are bronze-bushed at their small ends. The big end of the forked rod is fitted with a steel-backed lead-bronze split bearing, which bears directly on the crankshaft. This bearing is made with an outside surface of white metal at its centre to provide a bearing for the plain rod. Oil holes are drilled through the bearing to provide lubrication for the big end of the plain rod.

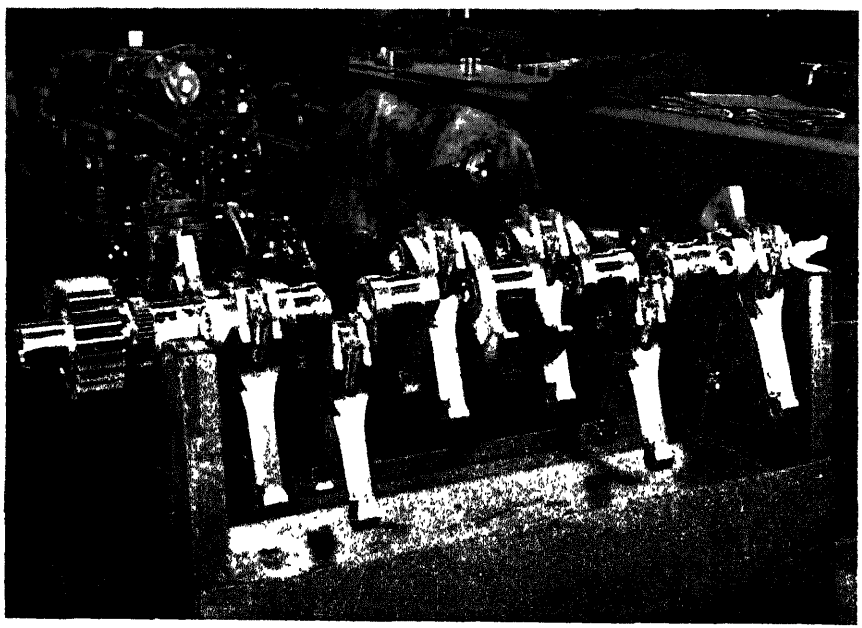

Fig. 3.—CRANKSHAFT, SHOWING CONNECTING RODS ASSEMBLED AND REDUCTION GEAR

Crankshaft

This is a nickel-chrome steel forging machined all over, and rotates in eight main bearings. Journals and crankpins are hollow, capped at both ends, and drilled to afford pressure lubrication for the big ends. The front of the crankshaft is machined to form driving dogs for the vacuum pump and airscrew governor, tapered and keyed for the reception of the airscrew reduction gear and machined to carry the driving gear for the camshafts and auxiliaries.

Airscrew Shaft

The airscrew shaft is machined all over from a forging of nickel-chrome steel, and is provided at its front end with splines on which the airscrew fits. Towards the rear a flange is provided, over which the large reduction gear is spigoted and bolted into place. The front end runs in a combined radial and thrust bearing fitted in the front cover. The shaft is hollow and internally splined at the rear to take the coupling for the supercharger driving shaft. The airscrew reduction gear (ratio 0·667 to 1) is of the single-spur type.

Crankcase and Top Cover

The crankcase is a deep-section elektron casting with seven massive cross webs, which carry the main bearing low down in the crankcase, thereby forming an extremely stiff box section. In addition, the case is reinforced on each side by integrally cast webbing, and additional strength is given by two transverse bolts at the centre main bearing. The main-bearing caps are held in position with studs, and are a push fit in between the boss webs which are machined accordingly.

At the front end of the crankcase the cross web carries both the second main crankshaft bearing and also a bronze-backed white-metal bearing which is pressed into the elektron of the crankcase and carries the rear end of the airscrew shaft. The cross webs are also bored at either side to take the bearings for the two camshafts.

The front of the crankcase is provided with facings to carry the two magnetos, while the rear of the crankcase is machined to form the facing on which the supercharger casing is fitted. The elektron top cover has an integrally cast housing at the rear which carries the starter gear and electric starter. The booster coil is also mounted on this cover. Inside on the L.H. side of the cover, a hole is cast from front to rear, which serves as the main oil gallery.

Camshafts

There are two steel camshafts, each with twelve integral cams. Each shaft runs in seven plain bearings housed in the lower part of the crankcase on either side. The five intermediate journals of each shaft are supported by bearings in the cross webs of the crankcase. The bearings are

of large diameter to enable the camshaft to be withdrawn from the front. The front and rear bearings are of magnesium alloy and duralumin respectively, and are held in position by dowel bolts and lockwashers which pass through the crankcase. The bearings are lubricated from the hollow camshafts in which oil is maintained at a pressure of 20 lb. per square inch. The spur gear driving the camshaft is vernier keyed to the extreme front end and secured by a nut and tabwasher.

Valve Operating Gear

Each cam operates a sliding tappet, which lifts the valve by means of the usual tappet rod and rocker mechanism, the closing of the valve and the return stroke of the tappet being accomplished by the action of the valve springs. The tappet is square ended at the cam end to prevent rotation, and is fitted with a ball end to engage the tappet rod. The tappet reciprocates in a flanged guide, housed and bolted in the crankcase. The tappet rod is of D.T.D. 130, fitted at the upper and lower end with a cup and ball end respectively. The steel rocker, which has a phosphor-bronze bush, pivots about its offset centre on a hardened steel spindle and is held in a stamped steel bracket.

At the tappet rod end the rocker is tapped to receive a hardened steel screwed cup end and locknut, by means of which valve clearance is adjusted. A hardened steel pad is riveted into the other end of the rocker. A telescopic cover encloses the tappet rod and seats outwardly under the action of an enclosed central spring against a Dermatine ring in the tappet guide flange at the crankcase and a similar ring in a recess on the top side of the cylinder head. The valves, rockers, etc., are completely enclosed by a cast elektron cover held in position on the under side of the cylinder head by a special nut.

Valves

The valves are of special alloy steel (exhaust, D.T.D. 49A, and inlet, S.62). The exhaust valve is stellited, a process which is found to be essential when running engines on a fuel containing certain tetra-ethyl lead content. The ends of both the exhaust and inlet valve stems are stellited also in order to withstand wear. Double concentric valve springs are fitted between the flange of the valve guide and the valve stem collar, which in turn is held in position on the valve with split taper collets.

Timing Gears and Auxiliary Drives

The camshafts and all auxiliaries other than the supercharger, vacuum pump, and airscrew governor are driven from a gearwheel mounted directly behind the reduction gear on the front end of the crankshaft. This is the steadiest part of the crankshaft, and provides the smoothest drive for the accessories. From the crankshaft gear the drive is taken through

double idler gears situated one on each side of the crankshaft to the two camshafts. Bevel gears integral with the front camshaft gears drive the two magnetos.

The rear of the "B" bank (L.H.) camshaft is splined externally, and drives a horizontal coupling shaft which drives the Dowty pump, generator, and metering pump at its rear end. It also drives, by means of bevel gears, the vertical shaft from the lower end of which the oil pump is driven. Machined integrally with the vertical oil-pump drive shaft are two wormgears which drive the dual revolution indicator and the fuel pump.

Supercharger and Induction System

The supercharger is bolted to the rear end of the crankcase, and is driven by means of a long driving shaft splined at its front end into a coupling in the rear of the airscrew shaft, and at its rear end into another coupling which drives through a layshaft the impeller of the supercharger. The impeller is machined all over from a forging of D.T.D. 130, and is dynamically balanced to enable it to run in ball bearings at a maximum speed of approximately 20,000 r.p.m. The impeller sucks the mixture from an S.U. carburettor fitted low down on the R.H. side of the supercharger casing, and compresses it to a pressure controlled by the cam on the automatic boost control to a maximum of 3½ lb. per square inch under take-off conditions.

On leaving the impeller, the kinetic energy of the mixture is converted into pressure by diffuser blades which pass the mixture into the delivery volute casing. From the delivery volute the mixture passes into a large main manifold between the banks of the cylinders. Four branch manifolds carry the mixture to the inlet ports on the cylinder heads.

Directly above the carburettor the mixture passes through a section of casing which is jacketed, and through which return oil from the engine is constantly fed. Hot oil is also fed to the two hollow butterfly valves on the carburettor itself, so that with the heater jacket all possibility of ice formation is obviated.

Oil Filters

The two scavenge filters, also one pressure and one suction filter, are contained in the same elektron casting which forms the main oil sump and carries the oil pumps. A long auxiliary felt pressure filter in which is incorporated a relief valve is bolted on to two facings provided on the oil sump. All filters are accessible for cleaning by unscrewing the hexagonal caps. The main pressure filter is of the Auto Klean type. Dismantling for cleaning is only necessary after every 250 hours' flying. The filter unit is removed by taking off the four nuts and split pins. The tommy bar, however, should be turned frequently in order to clear the filter.

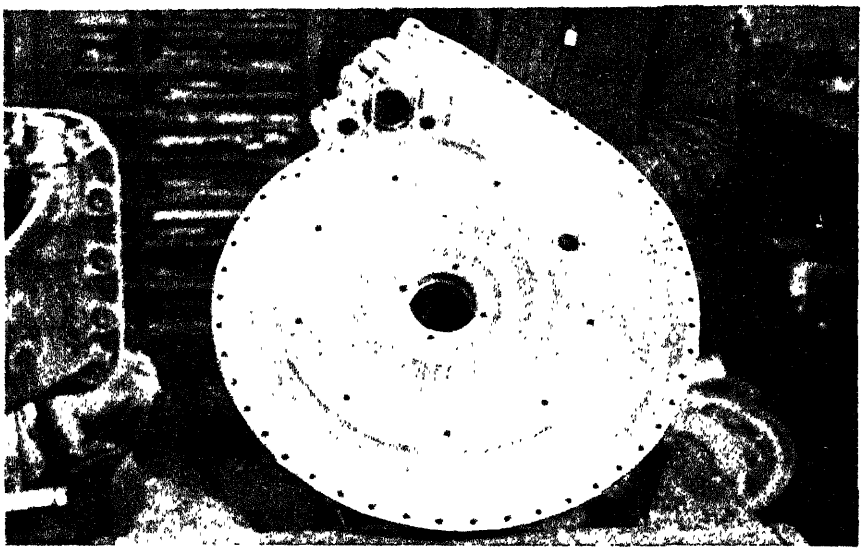

Fig. 4.—OUTER HALF OF SUPERCHARGER CASING

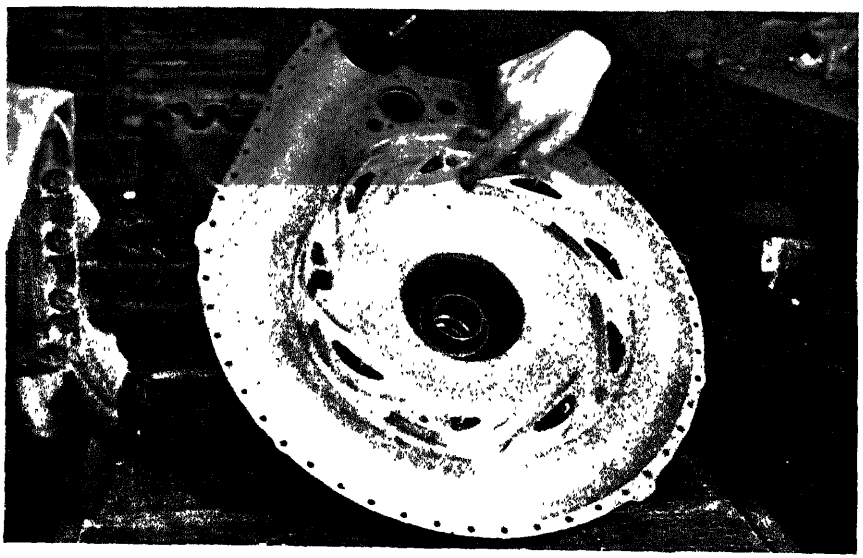

Fig. 5.—INNER HALF OF SUPERCHARGER CASING
Showing diffuser.

Lubrication

The oil pumps and filters form a detachable unit bolted on to the underside of the rear of the supercharger. A gear type pump in the oil sump draws oil from a separate tank via a gauze filter (situated in the L.H. side of the sump), and delivers under pressure to an Auto Klean filter which ensures the removal of the finest particles of foreign matter. The flow of oil then passes through the auxiliary filter (bolted to the oil sump) and thence to the engine in the manner described below.

By means of a relief valve and the aid of shims, the main oil pressure is adjusted to 60 lb. per square inch. After passing through the pressure filter the oil divides into two streams. The main stream flows upwards to the top cover and along a cast-in gallery connected by drillings to the crankshaft main bearings. The oil passes into the crankshaft through the hollow journals and crankpins to the big ends. This stream also lubricates the airscrew-shaft bearing, the rear main bearing, the camshaft idler spindles, and also supplies oil to the reduction gear oil jet.

The second stream passes through a balanced piston mechanism which automatically reduces the pressure to approximately 20 lb. per square inch. The oil at this reduced pressure lubricates the hollow camshafts, the magneto drives, and the accessory drives. The pistons, cams, and tappets are lubricated by the continual list in the crankcase caused by the oil splash from the main bearings, big ends, and camshafts. A drilling is provided in the R.H. camshaft rear bearing, which connects with a hole in the supercharger carrier case and serves to lubricate the supercharger layshaft. Holes in the layshaft gear assist in maintaining an oil mist which lubricates the gears. Oil is sucked from the crankcase by the depression existing in the supercharger casing and lubricates the front impeller bearing. The Tecalemit metering pump at the rear of the engine delivers oil to the rear impeller bearing.

Every important bearing is pressure lubricated, but the flow of oil is not excessive, and very little cooling suffices to maintain a reasonable working temperature for the lubricant. Oil for the airscrew governor is fed at engine pressure from the top cover to a drilling in the top facing (L.H. side of the crankcase). This drilling connects with the oil hole for the front main bearing. The oil flows to the drive housing and thence to the airscrew governor. The action of the governor increases the pressure to approximately 180 lb. per square inch. The oil is then fed to the rear airscrew-shaft bearing along the hollow shaft to the airscrew.

Oil collected in the crankcase and the base of the supercharger casing is scavenged by two gear-type pumps, also contained in the oil sump, through two scavenge filters, and delivered by means of an external pipe to the hollow spindles of the butterfly valves on the carburettor, thence to the oil jacket on the supercharger casing. The oil return pipe to the tank is connected to a union on the cover of the oil jacket.

To avoid excessive pressure in the spindles of the butterfly valves, a

bypass valve is provided in the supercharger casing which delivers return oil direct to the jacket. A centre screw type of fixing holds the valve-gear cover in place and the joint is sealed by a Hallite ring. Attached to each of these covers is a vent stand pipe to allow for the escape of excess oil and fumes. A plug is provided for filling, and also determines the level of the oil in the cover. The movement of the rockers splashes oil over all the moving parts of the rocker gear to effect lubrication.

Engine Controls

The engine controls are arranged for "Exactor" hydraulic operation. The three control units operate throttle, magnetos, airscrew governor, and four position mixture lever, the four positions being (1) automatic weak, (2) automatic rich, (3) extra rich for starting, (4) slow-running cut-off. The controls, however, can be arranged with lever pick-ups for rod operation, in lieu of the "Exactor type." By this method a lever with a ball end is attached to the rear end of the control shaft for connection to the control on the aircraft. The throttle and mixture controls are directly operated.

INSTRUCTIONS FOR DISMANTLING, INSPECTION, AND REASSEMBLY

Removal of Engine from Air Frame

Assuming that the airscrew has been removed, plug the hole in the airscrew shaft.

Remove all the engine cowling.

Disconnect electric starter leads.

Disconnect actuating levers from cooling flap and remove the oil supply pipe.

Disconnect all fuel pipes.

Disconnect all oil pipes.

Disconnect all engine controls.

Disconnect all connections to engine instruments.

Remove the joints from air scoops.

Remove exhaust manifolds.

Disconnect fuel doper pipes.

Disconnect L.T. ignition leads.

Remove generator and drive.

Remove Dowty pump connections.

Attach sling hooks.

Take the weight of the engine on slings.

Remove engine bearer bolts.

Lower the engine clear of air frame, and place on stand.

It should be realised that connections and controls will vary with different installations, but the above covers broadly the points to be

observed. It is important to ensure that all connections from aircraft to engine such as controls and pipe lines are disconnected at the engine end before lowering the engine clear of the air frame.

The sequence of operation for dismantling and assembling the engine should be strictly adhered to.

Removal of Induction Pipes, Ignition Equipment, and Controls

Remove the main induction pipe after first removing all attachments. It should be noted that the internal-spring supports on the manifold joints are individually cut to suit each joint. Remove the four branch pipes, and using a universal spanner, remove the nuts holding the pipes to the cylinder heads. Disconnect the plug leads, and remove the special screening, after which the distributors may be taken off. Using a box spanner and tommy bar, remove the sparking plugs. Both magnetos should now be removed.

Disconnect the flexible coupling at the rear end of the main centre control shaft close by the side of the carburettor. Remove controls from the hot and cold air intake breeches piece. Remove "Exactor" control units and pipes.

The carburettor and breeches piece may then be removed as one unit. Disconnect the flexible couplings from the control rod which actuates the airscrew governor, and disconnect the ball end connections on magneto control rods.

The front control casing may then be removed from the front cover by unscrewing the four nuts which retain it.

Removal of Supercharger and Top Cover

Unscrew the series of nuts holding the supercharger assembly to the rear of the crankcase and withdraw from position. If the horizontal oil-pump driving shaft tends to stick at the front end, it is advisable to pull it back into the supercharger casing during the removal of the above assembly. The supercharger drive shaft may now be withdrawn towards the rear.

Remove the nut and spring from the rear end of the suction oil pipe, and using the special extractor, withdraw the pipe from the crankcase.

Remove the front and rear baffles.

Withdraw the main centre control shaft.

Unscrew the nuts retaining the top cover to the crankcase, and lift off the cover complete with starter.

Removal of Valve Gear

Unscrew the centre nuts and remove the rocker covers. This should be done with the engine in its normal position, i.e. with heads down, so that the oil will not be spilled in the rocker covers.

Remove the clamping bolts holding the valve-rocker spindles in place

in the rocker brackets and using the extractor, withdraw the rocker spindles.

The rockers and tappet rods may now be removed.

Telescope the two halves of the tappet-rod casing tubes together, and remove from position.

Removal of Cylinder Heads, Barrels, and Pistons

Remove small baffles from between cylinder heads, and disconnect hinged baffles from clips.

Loosen all cylinder head nuts and ease cylinder heads clear of studs.

With piston at its outer dead centre, carefully withdraw the cylinder from the crankcase, supporting the piston as the cylinder is lifted clear. Should the cylinders be tight in the crankcase, striking them alternately sideways with the palm of the hand will loosen them.

Remove the nuts holding the cylinder baffle brackets to the crankcase.

Using an extractor, remove the circlip from one end of each gudgeon pin. Care should be taken to avoid damaging or burring the groove in the gudgeon pin during this operation.

Should a burr be accidentally raised, stone it off to prevent scoring of the bore in the piston boss and connecting-rod small end during removal of the gudgeon pin.

After removing the washers, the gudgeon pin may be pushed out and the piston removed.

If the gudgeon pin is too tight to be removed by hand, use a special gudgeon pin extractor.

Removal of Airscrew Governor, Vacuum-pump Assembly, and Starter Drive

Remove the four nuts and spring washers holding the airscrew governor and vacuum-pump drive assembly on to the front of the crankcase.

Bend back the lock washers and remove the seven setscrews.

The starter-drive assembly may then be withdrawn from the rear of the crankcase.

Removal of Front Cover Assembly and Airscrew Shaft

Remove split pins, slotted nuts, and plain washers. Using an extractor, withdraw the front cover assembly, and remove the distance piece from airscrew shaft, ensuring that the shaft remains in position.

Remove the oil baffle which is situated directly in front and at the base of the airscrew shaft gear, by removing the split pins and nuts which hold it in position on the web in the crankcase.

The airscrew shaft may now be withdrawn from its rear bearing.

Removal of Camshaft Idler Gears

Withdraw the magneto drives from the crankcase.

Remove covers, unscrew the nut, and remove washers from end of camshaft idler spindle.

The spindle will have to be removed, using an extractor, and the gears lifted from the crankcase.

Removal of Crankshaft and Connecting Rods

Remove the split pins and nuts holding the main bearing caps in position ; withdraw the two transverse bolts in the crankcase, then remove the caps by means of an extractor.

Lift the crankshaft complete with connecting rods out of position.

The lower halves of the main bearings may be lifted out of the half bores without difficulty.

Removal of Camshaft and Tappets

Unscrew the nuts and remove the tappets complete with guides.

Remove the camshaft covers from the front of the crankcase.

Bend back the tab of lockwasher and remove nuts and washers, then extract the gear.

Unscrew the dowel bolts which hold the camshaft front and rear bushes in place. These dowel bolts will be found on the outside of the crankcase.

The camshaft may then be pulled forward, together with the front bearing which is a push fit in its housing.

Dismantling of Supercharger

First remove the oil sump by unscrewing the nuts holding it to the supercharger casing.

Remove the generator drive, Dowty pump, and metering-pump drive assembly, and withdraw the small spring oil seal, and the horizontal bevel gear.

Slacken the layshaft bearing nut. This is a precaution to avoid any possibility of damaging the bearing which may occur if the nut is removed after the gear carrier has been removed. Next remove the gear and carrier, and then the diffuser sleeve, using the special extractor.

Unscrew all nuts from diffuser, and outside of supercharger casing, and split the two half-cases. Remove the four nuts from the impeller bearing, after which the impeller assembly may be withdrawn.

Holding the impeller gear with a special tool, unscrew the nut and press out the impeller spindle. Do not hammer out, as this may damage the bearing.

Remove the fuel pump and housing, using an extractor to do this, and then remove the revolution indicator drives. To remove the vertical oil-pump drive shaft, hold the shaft at its lower end with a special tool

and remove the screw at bevel gear end, after which the shaft and gear may be withdrawn from their housing. Now remove the bypass valve.

To dismantle the gear carrier, first remove the layshaft by unscrewing the aforementioned nut from the front of the shaft. Remove the circlip from inside of lay-shaft spindle, and withdraw the plug.

The main driving gear and coupling may then be dismantled by removing the split pin and nut which retain them in their housing.

Dismantling Top Cover

Unscrew the bolts which retain the booster coil and remove from top cover.

Remove the starter by unscrewing the six nuts and spring washers.

Unscrew the four nuts holding the cover plate in position, after which the starter driving gear may be removed.

To remove the starter idler gear, unscrew the nut and tap out the spindle.

Dismantling of Crankshaft

Remove split pins, and using ring spanner, unscrew the big-end bolt nuts of the auxiliary connecting rods ; similarly remove forked connecting rods.

Loosely assemble each connecting rod to ensure correct reassembly on crankshaft.

Bend back the locking tab and unscrew the nut which holds the crankshaft reduction gear in position.

Using an extractor, remove the gear and its two keys. Bend back the locking tabs, and using a ring spanner unscrew the nut which retains the small crankshaft gear ; this will allow the gear to be withdrawn from the shaft.

This gear is a press fit on the shaft, and must not be removed except for replacement.

Withdraw split pins, nuts, and bolts retaining oil seals, then remove the seals.

After removing split pin and retaining collar, withdraw the starter dog.

Dismantling of Cylinder Heads

The rockers and spindles having been removed, place the cylinder head over a small block of wood sufficiently thick to allow the valves to be held in place.

Using a valve spring compressor, depress the valve collar. The collets may then be removed from the valve stems. Remove the compressor and withdraw the springs and collar.

On removing the cylinder head off the wooden block, the valves may be withdrawn.

Should it be necessary to remove the valve guides, then an extractor must be used.

Remove the split pin and nut, then tap out the rocker bracket.

Dismantling of Pistons

Stand the piston on a bench with the skirt downwards and remove the rings.

Commence with the top ring, and slide all rings upwards, i.e. towards the crown of the piston.

Dismantling Front Cover Assembly

Remove the nuts and bolts retaining the nose piece to the ballrace housing, and remove the nose piece.

Unscrew the locking nut ; the ballrace, oil thrower, and oil seal may then be removed.

The coupling in the airscrew shaft may be withdrawn after removing the locknut and circlip.

Dismantling Oil Pumps and Filters

Remove the auxiliary pressure-filter casing by unscrewing the six bolts which hold it to the oil sump. The filter proper is accessible by removing the eight nuts which hold the end cap in place.

Remove the Auto-Klean pressure filter by unscrewing the four nuts from end cap.

The suction-oil filter is held in place by a hexagonal cap nut.

The two scavenge filters are also removed by unscrewing one hexagonal nut in each case.

The driven spindle of the pressure pump may be withdrawn through the bottom of the sump when the relief valve and housing have been removed.

To dismantle the pressure pump, first remove the nut at the top of the spindle, and using an extractor withdraw the coupling.

Bend back the locking tabs, and remove the nuts from the pump housing, which will allow the latter to be lifted from the studs.

Remove the gear and key from the driving spindle.

The key may be removed by tapping out from behind with a special punch, the spindle being drilled for the purpose.

Lift off the centre piece, and remove the next gear and key in the same manner as previously.

The driving spindle may then be withdrawn through the bottom of the sump.

Dismantling of Airscrew Governor and Vacuum-Pump Drive

Remove nut holding driving dog and extract dog.

Unscrew the four nuts holding the bevel gear housing. Remove housing and bevel gear.

Withdraw the cross shaft housing and horizontal bevel gear.

Dismantling Magneto Drive

Bend back locking tab and remove nut. Withdraw coupling and bevel gear.

The oil seal may then be removed from the adapter if necessary.

Dismantling Starter Dog Housing

Remove locking wires, unscrew the four nuts, and take off the springs. Remove cover, friction block, and plate.

The locking nut and lock washers may then be removed, and the dog and gear withdrawn from the housing.

Dismantling Generator, Dowty Pump, and Metering-pump Drive Assembly

Remove the metering pump; this is important, as it is liable to damage if left in position.

Then remove the bottom cover from the drive housing, and unscrew the screw from the base of the bevel gear. Next remove the Dowty pump by removing the six nuts and spring washers. It will then be possible to remove the coupling shaft. Remove the six nuts and spring washers which hold the drive housing adapter in place and remove the adapter, together with the bevel pinions and drive shaft.

To dismantle the bevel pinions and shaft from the adapter bend back the locking tab and remove the nut and washers.

Then remove the two bevel pinions. The drive shaft may now be withdrawn from the bushes.

Unscrew the four nuts and spring washers which hold the oil seal and flexible drive housing in place, and withdraw the assembly.

Remove the circlip and tap out the oil seal and coupling. Bend back the locking tab, remove nut and washer from bevel pinion and withdraw pinion.

Remove the metering pump camshaft cover by unscrewing the three nuts retaining it. Remove nut and lock washer, and tap out the metering-pump drive spindle. The remaining bevel gear may now be withdrawn from its housing.

Dismantling Generator Drive and B.T.H. Compressor Drive

Unscrew the six nuts and remove the complete housing from the supercharger casing, ensuring that the oil seal is removed from the main driving shaft.

Now remove the metering pump, then take off the six nuts and remove the cover carrying the metering-pump drive.

Unscrew the four nuts which retain the oil seal and flexible drive housing, then withdraw the assembly. Remove the circlip and take out the oil seal and coupling.

Bend back the locking tab, remove the nut and washers from the bevel pinion shaft, and withdraw the pinion.

This operation should be done by holding the pinion with a special tool.

Removing the Metering Pump

Remove the metering-pump camshaft cover by unscrewing the three nuts retaining it.

Remove nut and lock washer, then tap out the metering-pump drive spindle. Bend back locking tab, remove the nut, and the large bevel gear may be withdrawn.

Take out the six set bolts and remove the compressor, then unscrew the six nuts and remove the housing.

The metering pump should now be taken off.

Bend back the locking tab, unscrew the nut, remove the washer, and withdraw the driving spindle.

Dismantling Control Casing

Remove all nuts and washers from the large front cover and tap out the two fitting bolts. Now remove the cover. Extract the taper pin from the lever on rear of casing. This will allow the cam lever to be withdrawn.

A mark should be made on the teeth of the quadrant gear, and also the small gear on cam spindle to ensure correct reassembly.

Remove the two taper pins from the rear coupling and tap out the quadrant gear.

Unscrew the three countersunk screws and remove the small rear cover, and tap out the cam spindle, together with the cam wheel and gear.

A Precaution

Before the spindle is out completely, a mark should be made on the hexagonal part of the spindle and wheel to ensure correct reassembly.

Remove the cover inside the casing by unscrewing the nuts.

As a precaution before removing the control wire, a mark should be made on the serration of the wheel which comes opposite to the end of the wire.

Withdraw the wire and the wheel may then be removed. Take off the small dome-shaped cover from the lower end of the casing by unscrewing the two nuts. Remove slotted nut from end of spindle and dismantle the vernier adjustment pieces.

Remove top cover and withdraw the coupling and wheel.

Dismantling Hydraulic Ram for Cooling Flap

Remove the link pieces from lifting levers, then remove the levers.

Take out split pin, remove the slotted nut from rear of bracket, and withdraw the bolt and distance piece.

Remove setscrew from operating lever and withdraw the cross shaft. Depress the small collar, and remove the split pin from the pin which connects the operating lever to the end of piston rod ; the lever may then be removed. Disconnect the oil-feed pipes and remove taper pins, collars, and spindle on which the ram cylinder swivels.

Take off the front cover, pull the piston down to the rear end of the cylinder, then unscrew the rear cover.

Remove cover, stop ring, oil seal, and piston.

The cover, together with the oil seal and stop ring, can then be withdrawn from the piston rod.

All parts should now be thoroughly cleaned, decarbonised, and laid out ready for inspection.

Inspection

After the engine has been completely dismantled, the following points should be observed during the subsequent inspection.

Inspection of Cylinder Heads

Examine the cylinder heads for cracks.

Examine the valves for any signs of pitting, and examine the stelliting for cracks.

Any sign of picking up or roughness on the valve stems should be smoothed off and polished with superfine emery cloth. If the valve guides or stems are worn beyond the repair tolerances, new parts should be fitted. Always use an extractor to remove the valve guides, and on replacement use a soft drift to avoid damaging the ends of the valve guides.

The nut holding the valve rocket bracket should be checked for tightness, and if slack, tightened up and a new split pin inserted.

Check the fit of the rocker bush on the spindle and examine the rocker pads for wear.

The rocker pads may be stoned if wear is slight, but if the contour of the pad is affected, a new pad should be riveted into the rocker.

Examine the cup end in the rocker and the ball ends on the tappet rod for pitting or wear.

Check the tappet rod for straightness. Examine the steel valve seatings in cylinder heads for any movement or cracks.

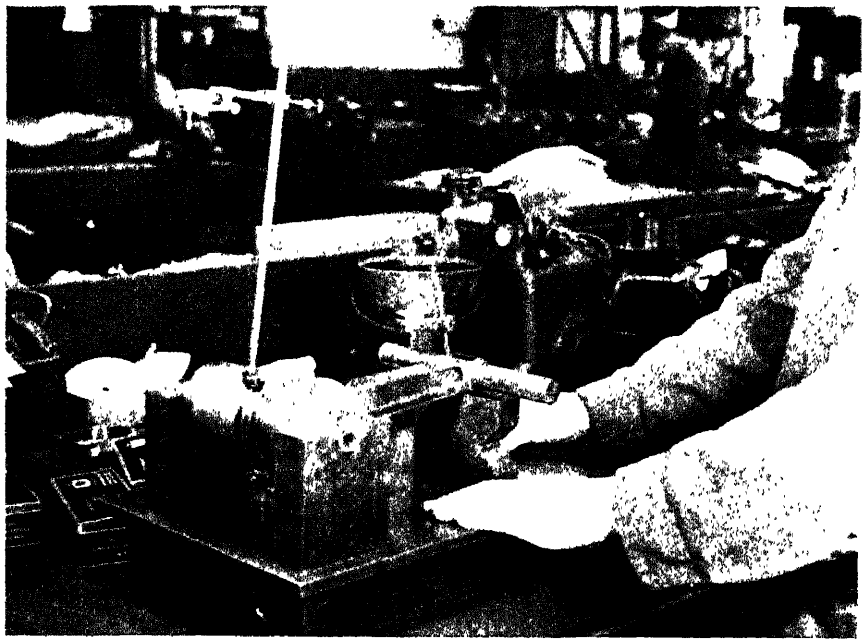

Fig. 6.—CHECKING SMALL- AND BIG-END BORES TOGETHER FOR CORRECT ALIGNMENT (1)

Inspection of Cylinders and Pistons

Check the cylinder for wear, ovality, and scoring of the bore.

The piston should be checked for cracks, wear in the gudgeon-pin bores, wear in the ring grooves, and wear on the diameter.

Piston rings should be examined for blowing by loss of spring or excessive gap.

Insert the piston in the cylinder and use the crown for squaring the rings while checking the gap.

Fit the piston rings to the piston for checking the ring-groove clearance ; before doing this make sure that the ring grooves are free from carbon.

Examine the gudgeon pin for wear or cracks ; check the fit in the connecting rod and piston.

The rings should be squared and the gap checked at the extreme outer end of the cylinder barrel, i.e. where the bore is the smallest diameter.

It should be remembered, during these checks and examination, that the cylinder barrels of the " Gipsy Twelve " engine are a tapered bore.

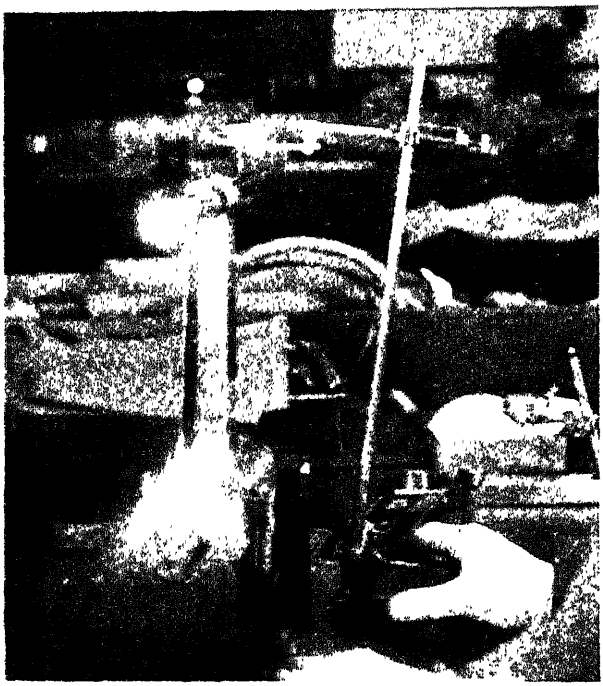

Fig. 7.—CHECKING SMALL- AND BIG-END BORES TOGETHER FOR CORRECT ALIGNMENT (2)

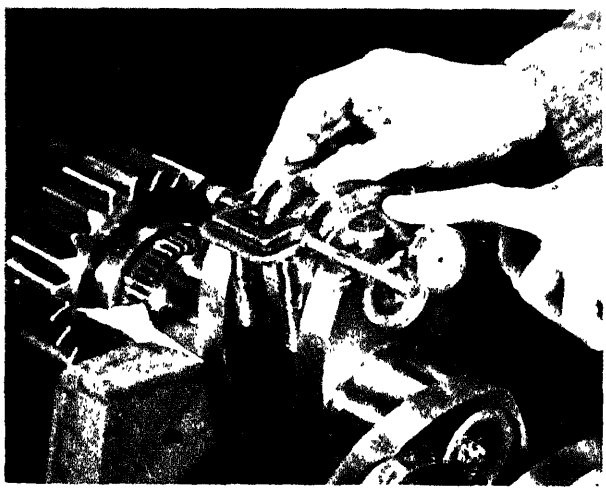

Fig. 8.—ASSEMBLE BOTH CONNECTING RODS AND CHECK FOR CLEARANCE AND END FLOAT

Inspection of Connecting Rods

Check the small-end bores for ovality or wear, and the small- and big-end bores together for correct alignment.

Check the security of the small-end bushes.

Examine the connecting-rod bearings for cracks, scoring, or adhesion of the metal.

Assemble both connecting rods and check for clearance and end float.

The caps should never be faced off in order to rectify worn bearings. It is always recommended that new bearings be fitted.

Inspection of Crankshaft and Gears

The crankshaft should be examined for scores, eccentricity, and ovality of the journals and crankpins. If the scores are deep, or the eccentricity or ovality is outside the tolerance

limits, the shaft should be re-ground. A schedule of fits, clearances, and repair tolerances to be worked to during overhaul is included in the manufacturer's handbook.

Check the alignment of the airscrew shaft.

The splines at the airscrew end should be examined for damage. If slight burrs are noticeable, they should be carefully stoned off.

Inspect the bronze cone for wear.

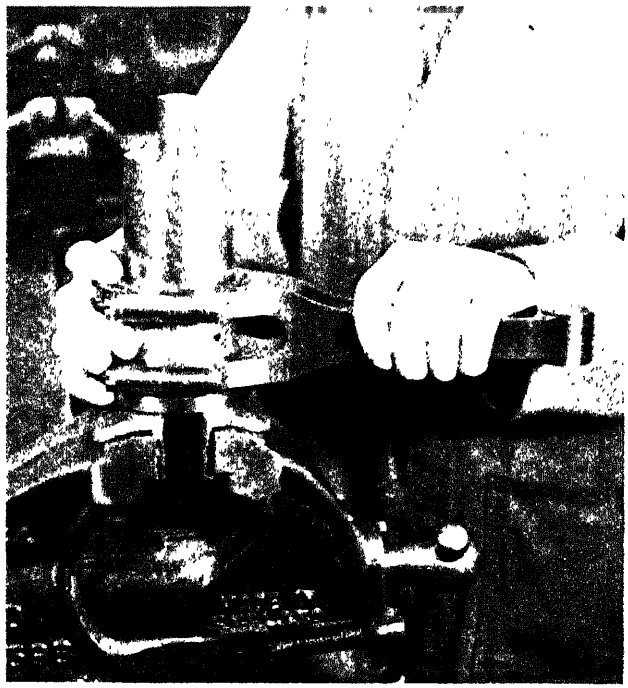

Fig. 9.—CHECKING BIG-END BORE FOR WEAR

Remove at least two of the bolts from the airscrew shaft reduction gear and examine for wear.

Examine both reduction gears for chipping, wear, or pitting.

If chipping is not pronounced and is confined to the edges of the teeth, these places may be stoned smooth.

Worn or badly pitted gears must be replaced.

Check the backlash of the gears.

Wash the thrust race, and examine for any signs of roughness or pitting of the balls. If at all defective, fit a new bearing.

Inspection of Main Bearings

The main bearings should be inspected for cracks and scoring.

Assemble the bearings in the crankcase, and check for clearance on the diameters of the crankshaft. Do not face off caps to rectify worn bearings.

It is important and essential, when the above examination is being carried out, that the two transverse bolts are in position in the crankcase.

Inspection of Crankcase and Camshaft

Examine the crankcase for general condition and signs of cracking.

Check the tightness of the main bearing studs and all other studs.

Look for signs of flaking of the case, chipped edges on cams, and general condition of the bearings.

Any roughness on the cams should be removed by careful stoning.

Examine main bearing dowels for tightness in the case.

Inspection of Plain Bearings and Tappets

Examine all plain bearings for tightness, fit, and general condition with the two transverse bolts in position.

Check the fit of the tappets in the guides and examine the condition of the bearing faces.

Examine the heel of the tappets for flaking, cracks, and contour.

Inspection of Supercharger and Oil Sump

Examine the oil sump for cracks.

Check backlash of oil-pump gears, and examine spindle bearings. Examine the oil-pump gear housings for scoring.

Carefully inspect both halves of the supercharger casing for signs of cracking.

Examine the impeller and carefully inspect the impeller bearings.

The impeller should be cleaned with metal polish.

On no account should abrasive material be used.

Examine the supercharger gears for wear or chipping and check all backlash.

Inspection of Hydraulic Ram

Examine the cylinder bore.

Examine the piston oil seal and the rear cover seal.

Inspect all link pins and bushes for wear.

Inspection of Accessory Drives

All accessory drive boxes should be stripped and the condition of gears and pinions inspected.

Check backlash on gears and examine bushes and spindles for wear on diameters and end float.

Finally, the induction manifold should be inspected and tested under pressure.

REASSEMBLY AFTER COMPLETE OVERHAUL

After all parts have been examined, faulty parts replaced, and valves ground in, the engine is ready for assembling.

The following parts should be renewed :

Dermatine ring between cylinder flange and crankcase.

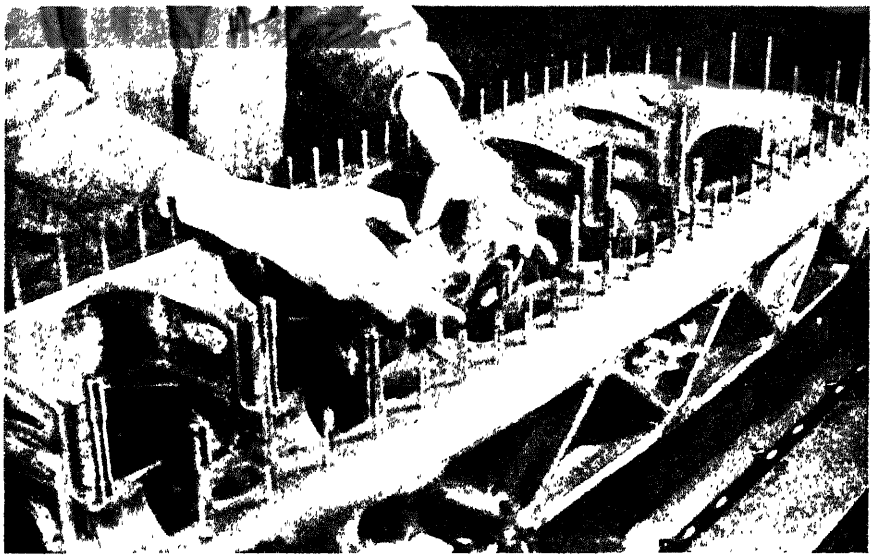

Fig. 10. FITTING THE HALF MAIN BEARINGS IN CRANKCASE

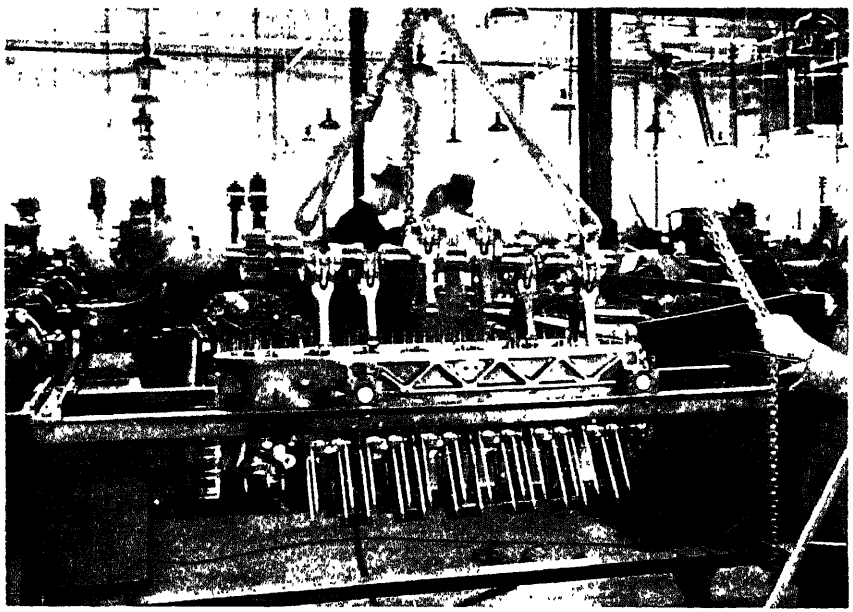

Fig. 11.—LOWERING THE CRANKSHAFT AND CONNECTING RODS INTO THE CRANKCASE

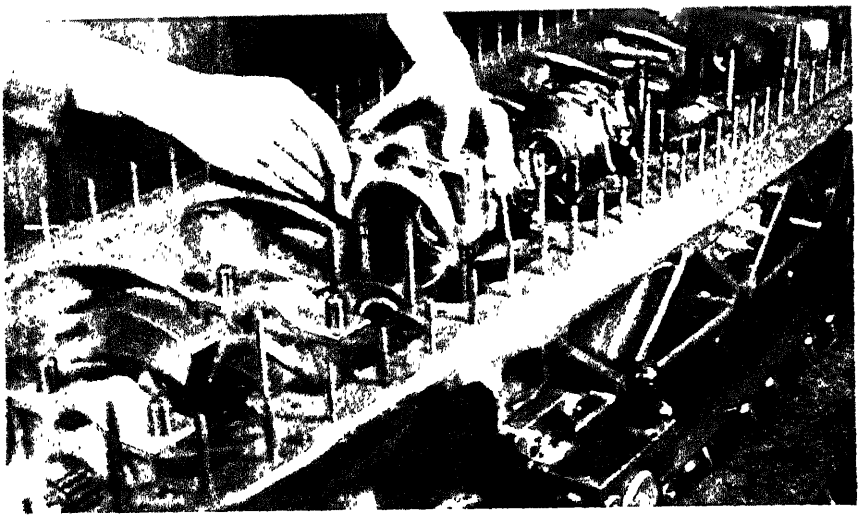

Fig. 12.—REPLACING MAIN BEARING

Dermatine rings at each end of tappet casing tubes.
Dermatine ring—tappet guide flange.
Dermatine joint ring—adapter—magneto.
Copper asbestos washers throughout oil system.
Copper asbestos washers on cylinder heads.
Copper asbestos washers on induction and exhaust ports.
Copper asbestos washer—airscrew feed pipe.
Hallite washers—flanges of supercharger to carburettor.
Hallite washer—breather—oil sump.
Hallite washer between supercharger and induction manifold.
Hallite joint—pressure reducing valve—crankcase.
Hallite joint—flange on crankcase breather.
Hallite joint—airscrew governor and reduction gear casing.
Hallite joint—vacuum pump—vacuum pump drive.
Hallite washers—breather—supercharger.
Graphited Hallite joint between cylinder head and valve rocker covers.
Paper washer between fuel pump and housing.
Paper washer between carburettor and supercharger.
Paper washer between oil jacket cover on supercharger.
Paper washer between side cover, oil jacket on supercharger.
Paper washers—Auxiliary filter and Auto Klean filter.
Red fibre washer—fuel pump.
Red fibre washer—banjo—vacuum pump connection.
Red fibre washer—thumb nut on valve covers.

Red fibre washer—reduction gear oil jet.
Rubber washers—diffuser sleeve.
Rubber joints—main induction branch and manifold.
Rubber sleeves on tappet rods
Copper joint ring—front cover on hydraulic ram.
"Gaco" piston oil seal in hydraulic ram.
Oil seal in rear cover—hydraulic ram.

Reassembly of Suction Oil Pipe and Gear Jet

Insert the suction oil pipe in the crankcase, and ensure that the rubber gland ring is in place under the collar of the pipe.

Replace the spring and lock with the nut.

Replace reduction gear oil jet in the crankcase.

Reassembly of Camshaft and Tappets

Fit the camshaft in the crankcase and replace the front bearings, taking care to ensure that the dowel holes are lined up with the dowel bolt holes in the crankcase.

The "B" bank left-hand camshaft is splined at the rear end.

Replace the tappets and guides and lightly screw up the nuts.

They should then be lined up with the cams to ensure full line contact and then finally tightened up.

Reassembly of Crankshaft and Connecting Rods

When replacing the crankshaft gear on the crankshaft, press the gear right home until tight against flange on shaft with dog engaged, then replace nut and lock washer. Never use the nut for pressing the gear on to the shaft.

The crankshaft reduction gear and its two keys may now be replaced, then fit the oil seals to the crankshaft.

Careful note should be made, when fitting the connecting rods, that both plain and forked rod are correctly fitted on the crankshaft; these are marked 1A, 1B, etc.

The bolts and nuts are also numbered.

The big-end nuts should be pulled up tightly, using the special spanner issued by the makers of the engine.

It is important that no other spanner but this is used, as this is made to a length which will ensure correct tightness of the nut.

Fit oil seal and starter dog, then screw up retaining bolt.

Fit the half main bearings. Care should be taken to see that they are correctly fitted as numbered.

Lower crankshaft and connecting rods into the crankcase.

Next insert half main bearings in caps; these are also numbered. Replace the main bearing caps, insert the transverse bolts, and pull up

bearing nuts tightly, using the special spanner. Now tighten the transverse bolts.

The crankshaft should turn quite freely by hand.

It is advisable to prime the oil connection in the crankcase with oil under pressure, using the oil test gallery provided in the overhaul tool kit.

Reassembly of Camshaft Idler Gears

Hold the camshaft idler gears in place in the crankcase with small gear to the front and insert the spindle.

Replace the washers and screw up the nuts.

It is advisable to fit the cooling baffle brackets to the crankcase at this stage and replace the baffles and hinge pins.

Reassembly of Pistons and Cylinder Barrels

When assembling the cylinder heads, first insert the valves, the largest diameter valve being the inlet.

Refit the rocker brackets to the head, so that the split clamp bosses are to the inside.

Lock the brackets in place with the nuts, washers, and split pins, using the special spanner.

Place a thrust washer either side of each rocker, then insert the spindle and lock with the clamping bolts.

Fig. 13.—VIEW SHOWING FLANGE ON CRANKCASE TO WHICH THE SUPERCHARGER IS BOLTED

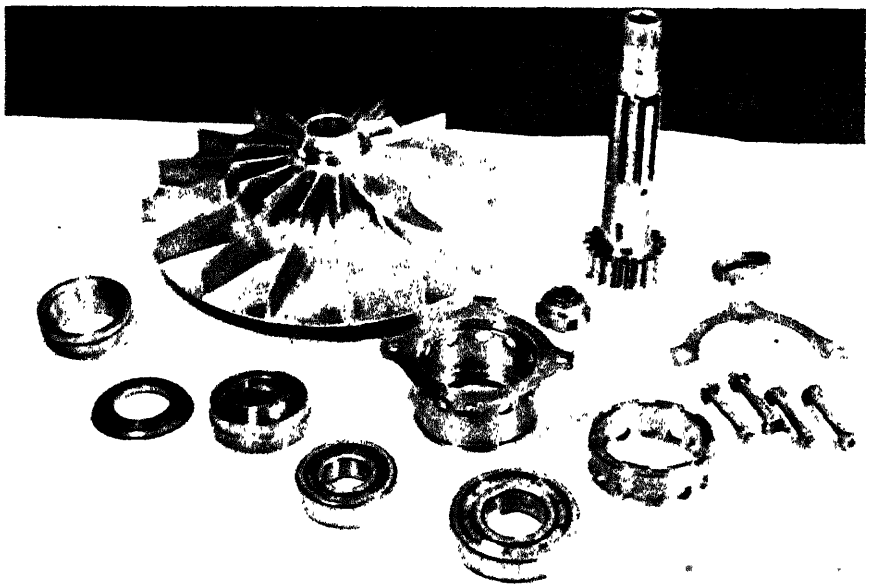

Fig. 14.—IMPELLER, SPINDLE, BALLRACES AND HOUSING, ETC.

Place the cylinder head over a block of wood to hold the valves in place, then replace the valve springs and collars, using the valve spring compressor and replace the collets on the valve stems.

Now replace the cylinder-head baffles.

Tightening the nuts just sufficiently to hold the heads in place, line the heads up with a straightedge against the facings provided for this purpose near the port facings.

The cylinder-head nuts should be tightened up opposite corners alternately, using the special spanner.

At this stage it is advisable to proceed with the valve timing, using a tappet rod fitted without its casing in No. 1 cylinder, exhaust valve tappet, of both "A" and "B" banks.

Drop the spring into the tappet rod casing and replace the short inner casing. Pass the tappet rod through the casing so that the cup end of the tappet rod is at the same end as the short inner casing.

Place the ball end of the tappet rod in the cup end of the valve rocker. Press the rocker arm down against the action of the valve springs and telescope the casing.

This will allow the tappet rod to be engaged with the ball end of the tappet and the casing with its seating in the tappet guide.

The cam should be in the neutral position during this operation.

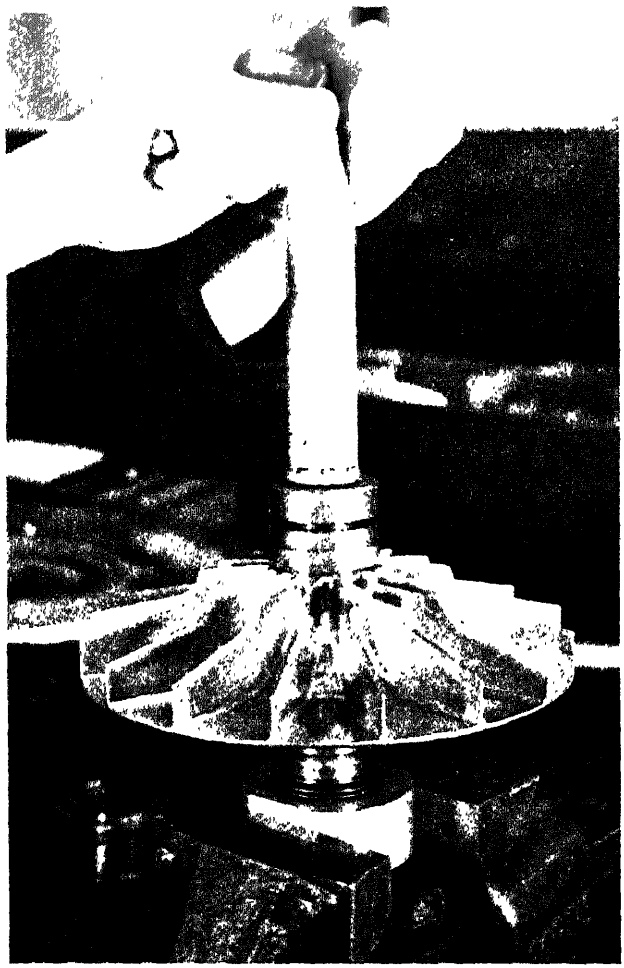

Fig. 15.—Assembling impeller unit

Valve Timing

Place the timing plate over the two studs on the right-hand side of the air-screw governor drive facing.

The timing disc is then placed in the end of the crankshaft, the dowel on the disc registering with the slot marked "A."

Turn the crankshaft in the direction indicated by arrow on the timing disc until the E.O. "A" bank mark lines up with the mark on the timing plate.

Set exhaust valve clearance on No. 1 cylinder "A" bank to ·090 in.

Turn "A" bank camshaft anti-clockwise until the setting clearance of ·090 in. is taken up and exhaust valve just commences to open, then, with crankshaft and camshaft set thus, fit camshaft gear, selecting a suitable keyway from the four provided.

The camshaft must be held against end movement when the gear is fitted. The accuracy of the setting obtained should be checked by turning the crankshaft in the opposite direction to arrow on timing disc about a quarter of a turn, then slowly return in direction of arrow, checking the opening of exhaust valve in the meantime.

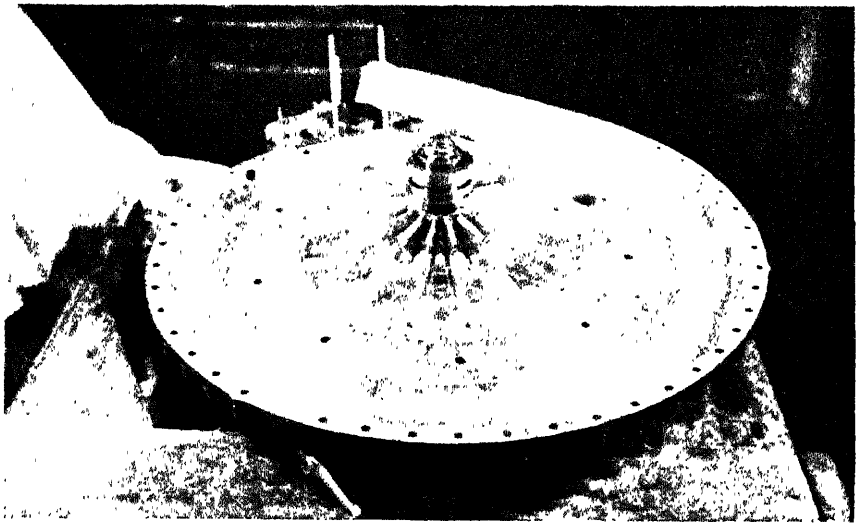

Fig. 16. VIEW SHOWING IMPELLER ASSEMBLY FITTED TO HALF OF SUPERCHARGER CASING

If correct, the valve should just commence to open when marks on timing disc and timing plate line up.

Turn the engine one complete revolution in direction of arrow, and continue to turn until E.O. "B" bank lines up with the mark on the timing plate and repeat operation.

Reassembly of Magneto Drive

Refit the oil seal, bevel gear, and coupling in the magneto drive adapter, and lock in place by means of the nut and lock washer.

Offer up the assembly to crankcase, so that the bevel gear of magneto drive meshes with the bevel gear of camshaft.

To obtain the correct backlash on the gears, shims should be placed between the flange of the adapter and crankcase.

Magneto Timing

Turn the crankshaft until the mark of 35° before O.D.C. on timing disc lines up with the mark on timing plate, and exhaust valve of No. 6 cylinder on "A" bank is open.

Set magneto with contact-breaker lever against full advance stop and with points about to break, when main contact of inner rotor is at left-hand bottom corner looking on distributor end, with magneto in the upright position.

Offer up the magneto drive in the crankcase.

Any adjustment which may be necessary to engage the driving dogs

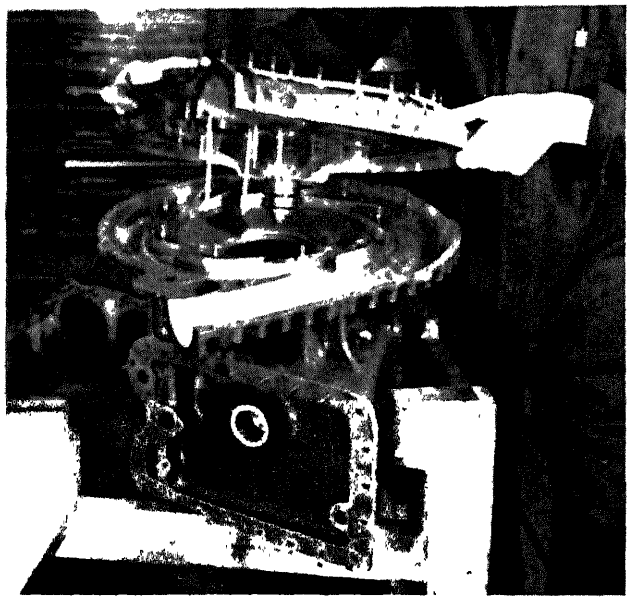

Fig. 17. FITTING THE HALF CASES OF SUPERCHARGER TOGETHER

may be made with the vernier coupling.

Reassembly of Front Cover and Airscrew Shaft

Replace the coupling in the airscrew shaft with the locknut and circlip.

Refit the shaft into its bush in the crankcase.

Replace the oil baffle in front and at the base of the airscrew shaft gear.

When reassembling the front cover, first fit the oil seal to the ballrace housing, then the oil thrower and ballrace, and lock in place with the locknut.

This small assembly should then be pressed in and bolted to the nose-piece.

After fitting the distance piece to the airscrew shaft, the whole front cover may be fitted and bolted to the crankcase.

The rear cone may then be fitted in position.

Pass the supercharger drive shaft through the bores in the crankcase, and connect up with the splines of the coupling in the rear of the airscrew shaft.

Reassembly of Starter Drive

Fit the starter gear and dog in their housing and replace the washers and nut.

Place the friction plate over the four studs ; the friction block may then be wound on over the spirals cut in the end of the dog. Replace the cover and springs, and retain by means of the nuts and locking wires.

Refit the complete assembly to the crankcase, ensuring that the dowel locates in the hole and replace the setscrews.

Reassembly of Oil Pumps and Filters

Assemble the driving and driven spindles in their housings, then temporarily refit the bottom cover containing the relief valve.

Replace the first pair of suction wheels, and lower the centre piece into position over the studs.

It is essential, when fitting the centre piece, to ensure that the transfer oil channel (in the form of an elongated hole) is placed uppermost.

Assemble the next key to the driving spindle and then the second pair of suction wheels.

The suction housing may now be placed in position over the studs and tightened down.

Assemble the two keys for the driving coupling and then replace the coupling, plain washer, etc.

All spindles should run freely when the nuts are finally tightened.

Always use an approved jointing compound on the joint faces.

Replace the oil filters and hexagonal caps.

Reassembly of Hydraulic Ram

Place the stop ring in the rear cover and screw the latter on to the cylinder.

Refit the piston to the cylinder from the front end, and replace the front cover nut. The piston should be free in the cylinder.

Refit the clamping bolt and distance piece to bracket and replace washer, etc. Place the operating lever in a convex position to the bracket and insert the cross shaft.

It will be noted that there are indentations on three or four of the serrations on cross shaft, and when assembling the centre-mark serration should line up with the slot in lever ; the indentation will then be in the correct position to receive the setscrew.

Refit the lifting levers to cross shaft with slot in levers to centre-marked serration as before, then replace setscrews.

Refit the cylinder bracket and replace the swivel pin.

Connect the operating lever and piston rod together.

The oil connections should now be lined up and the rear cover nut tightened. Lock the covers with locking wire.

Reassembly of Supercharger and Accessories

Place the oil thrower on the impeller spindle with chamfer of thrower against face of gear. Fit the ballrace into the impeller bearing housing and replace the nut.

The slot in the nut must come opposite to one of the studs in the impeller bearing housing to take a lock washer.

Press the impeller spindle with the oil thrower and ballrace assembly together. This assembly may now be bolted to the front half of the

supercharger casing, but in one position only, since it is located by one bolt larger than the rest.

The front cone, locating collar, rear cone, and ballrace may now be assembled in that order, using the special tool provided in the kit to press on the impeller. Lock the impeller spindle in place with the cap nut and lock washer.

It is important that the holes in the impeller line up with the holes in the spindle.

Fit bearing housing to rear of supercharger casing. A hole is drilled in the housing to locate with a dowel pin in the supercharger casing.

Now fit the diffuser and a new rubber ring, but before doing so locate the diffuser by inserting the diffuser sleeve and replace two countersunk screws.

Using an approved jointing compound, fit the two half cases together and insert the two dowel bolts.

Replace the diffuser sleeve with new rubber washer and lock in place with nuts and lock washers.

The two half cases may now be finally bolted together by first fitting the eight cap nuts and washers, and then the bolts on the outer edge of the casing.

Using the special gauges provided in the overhaul tool kit, the impeller should be checked for clearance in the following manner:

Slack back knurled centre screw of gauge. Screw gauge into tapped hole provided in the supercharger casing.

Rotate the impeller and slowly screw down the centre screw until it is heard to touch the impeller.

This should be done with the supercharger in its normal operating position.

Remove gauge from casing, taking care not to disturb the setting of the screw.

Measure the distance from the shoulder of hexagon to top of centre screw with a micrometer.

The figure obtained should be added to the figure marked on the casing boss and the sum subtracted from the figure marked on the top of the centre screw.

The resulting figure represents the clearance between the impeller and the casing.

It should be noted that the impeller assemblies are not interchangeable with volute casings.

Fit the bevel-gear pinion and vertical shaft which drives the oil pump into their bushes and retain with the locking screw and washer at the top of the bevel pinion.

Replace the revolution indicator drive gears, housings, and cover, and secure them with the nuts and spring washers.

Place the fuel-pump drive spindle in the housing, replace washer, and press gear on to spindle.

Lock in place with nut and lock washer.

Replace the inspection cover with six countersunk screws.

With a new paper washer, refit the fuel pump (if fitted on the engine).

The horizontal bevel gear may now be fitted into its bush in the supercharger casing. Insert the spring oil seal and fit the generator, Dowty pumps, and metering-pump drive assembly.

Shims should be placed under the flange of this assembly in order to obtain the correct backlash and end float on the gears. This check should be made before fitting the breather.

It must be remembered that no washer is fitted between the metering pump and the case.

Connect the metering-pump pipe to union on supercharger.

Fit breather and two Hallite washers, then replace the bypass valve.

The main driving gear and coupling may now be assembled in the gear carrier and locked in place.

Fit the plug in the layshaft and retain with the circlip.

Replace the gear and thrust washer on the shaft, and fit the seventeen rollers to the outer race. Replace the inner race and lock with nut and lock washer.

Using an approved jointing compound, fit the gear carrier to the supercharger casing, locating by means of the dowel bolts.

Fit the oil sump, using jointing compound, then replace the carburettor, using a new paper washer at the joint face.

Fit horizontal drive shaft into the splines of the horizontal bevel gear.

Take particular care at this stage to see that the spring-loaded oil seal is in position.

Replace the boost-pressure balance pipe and the oil-return pipe from supercharger to carburettor.

It will be noticed that on the lower part of the supercharger one stud is much larger than the others, and care should be taken to see that the nut on this stud is tightened up progressively as the supercharger is being fitted to the crankcase.

Refit the induction manifolds and tighten up the nuts progressively.

Reassembly of Control Casing

Replace the coupling and wheel in the small end of the control casing and replace the large cover. Loosely assemble the vernier coupling and dome-shaped cover (final adjustment to be made when control casing is fitted to engine).

Thread the control wire through the tubing from the small end of casing. Place the wire round the wheel at large end of casing, so that the end of wire comes opposite the mark on serration of wheel, and replace the wheel cover.

Refit the small cover on driving side of casing to prevent the ballrace

being tapped out when replacing the cam spindle. When replacing the cam spindle and cam, care should be taken to ensure that the marks on the hexagonal part of spindle and wheel line up. Replace the quadrant gear, again lining up the marks on gear teeth. Refit the coupling and the two taper pins.

Replace the cam lever on rear of the casing, then tap in the taper pin. Check that full travel is obtained on the cam wheel. Screw on the front cover nuts, replacing the two fitting bolts before finally tightening all round.

Fit the control casing over the four studs on the base of the front cover.

Reassembly of Airscrew Governor and Vacuum-pump Drive

Replace the cross-shaft bevel gear into its housing, then fit the cross shaft and housing.

Next assemble the small bevel gear into its housing with the driving dog, after which it can be fitted to the cross-shaft housing, care being taken that the correct number of shims are inserted under the flange to give the correct backlash.

Fit the assembly to the crankcase so that the driving dog engages with the dog on the end of the crankshaft, and secure in place with four nuts and spring washers.

Bolt the airscrew governor on to the left-hand side of the drive (taking particular care to see that the coupling is in place) and the vacuum pump on the other side.

Reassembly of Top Cover

Hold the idler gear in place in the top cover tap in the spindle, and screw up the nut.

Insert the starter gear and replace the small elektron cover, and retain with the four nuts and spring washers.

Replace the starter and screw up the six nuts evenly all round. The booster coil can then be fixed in place.

Before the top cover is fitted to the case, it is advisable to carry out a final oil check, using the test oil gallery supplied with the overhaul tool kit, oil being pumped through to ascertain that the oil is reaching all points.

Use an approved jointing compound, replace the top cover, and screw up the nuts firmly and evenly all round.

Replacing Valve-rocker Covers

Set the valves to the running clearance of 0·005 in. for inlet and exhaust.

When replacing valve-rocker covers, tighten up the central nut just sufficiently to make an oiltight joint between the cover and cylinder

head. Remove the oil-level plug from side of rocker covers, and pump in engine oil until it commences to flow back through the hole, then replace the plug.

Running-in Engine after Complete Overhaul

Motor over or drive by external means for two hours at approximately 300 r.p.m. (necessary only when major components have been renewed).

Run for two hours' endurance test.

Strip and examine replaced parts.

Final run for half an hour for power checks.

Note.—When assembling the engine, all clearances, end floats, and backlash should be carefully checked as each operation is carried out, the Fits and Clearances Chart being strictly adhered to.

RECOMMENDED MAINTENANCE SCHEDULE "GIPSY TWELVE" ENGINE

The "Gipsy Twelve" aero engine will normally be inspected and maintained by licensed ground engineers, and their training will indicate the nature of the inspection routine and work which is normally carried out to ensure reliable operation.

As a guide, however, the following covers, generally, the points to be observed.

Daily in Preparation for Flight

Pilots' reports should have attention.

Check all controls for free movement and normal operation.

Inspect engine and installation to ensure that there is no slacking, displacement, chafing, or leaks.

Check tightness of all nuts.

Rotate spindle in Auto-Klean filter.

Ensure that engine cowling is securely fastened.

Top up air-compressor oil reservoir with castor oil to Specification D.T.D. 72.

Run-up engines and check ground r.p.m. and boost.

After every 50 Hours' Flying

Routine daily schedule, including the following:

Remove sparking plugs, dismantle, clean, reassemble, and pressure test.

Check valve-tappet clearances, and reset if necessary.

Remove and clean the pressure and scavenge filters and renew the C. and A. washers.

Remove the Auto-Klean filter and clean, including the casing.

Remove the Tecalemit felt filter and replace with a new one.

Remove the jet well and clean, then flush through carburettor by operating fuel pumps.

Drain the oil system, including valve-rocker covers, and replenish with new oil.

Check contact-breaker gaps, and reset if necessary; clean the distributors and covers.

Clean out boost pipe (induction pipe to carburettor).

Ensure that all joints in oil-suction system and fuel-suction systems are tight.

Inspect push-rod casing rubbers, and renew if these are softened by action of heat and oil.

Lubricate all controls and also the generator drive.

Complete Overhaul

The manufacturer's handbook should be referred to for the overhaul period of an engine, since this period is subject to amendment.

INSTALLATION

The engine feet are attached to four vertical facings provided on the sides of the crankcase. A turned recess is machined in each of these facings, into which the engine foot spigot fits. Thus the shear load is taken off the four studs provided for fixing the engine feet. The feet are arranged for a trunnion fixing, and are mounted in Dynaflex rubber-in-shear mountings.

Cooling

The circular cowling of the " Gipsy Twelve " terminates at the front, without break of line, in a through-type airscrew spinner of efficient profile. This clean entry is not impaired by external airscoops for cooling the engine.

The " Gipsy Twelve " has been designed for cooling by ducts from the rear. The ducts deliver air at controlled pressure from orifices which are incorporated in the leading edge of the wing.

This cooling air entry is located in the leading edge of the wing, where the pressure of the slipstream is at its greatest.

The air is forced at pressure to galleries outside the banks of cylinders through ducts which follow an easy sweep and are unobstructed by auxiliary units. Thence it flows over the fins of the cylinders and heads to the space between the banks, and is exhausted downward and rearward. Control of the air flow is effected by an air-exit gill located on the underside of the engine nacelle.

In the fully open position for take off, this gill induces a suction which assists the slipstream pressure in forcing air over the engine.

Reference to the layout in diagrammatic form shows that air enters the openings A1 and A2 in the leading edge of the wing, and from there is

led through fixed ducts to scoops B1 and B2, one on the outside of each bank of cylinders.

These scoops are removable for access to the sparking plugs, and are joined to the fixed ducts in such a manner that movement of the engine in the airframe cannot impose any load on the fixed ducts.

After passing between the cylinder and head cooling fins, the air escapes through the controllable gill C.

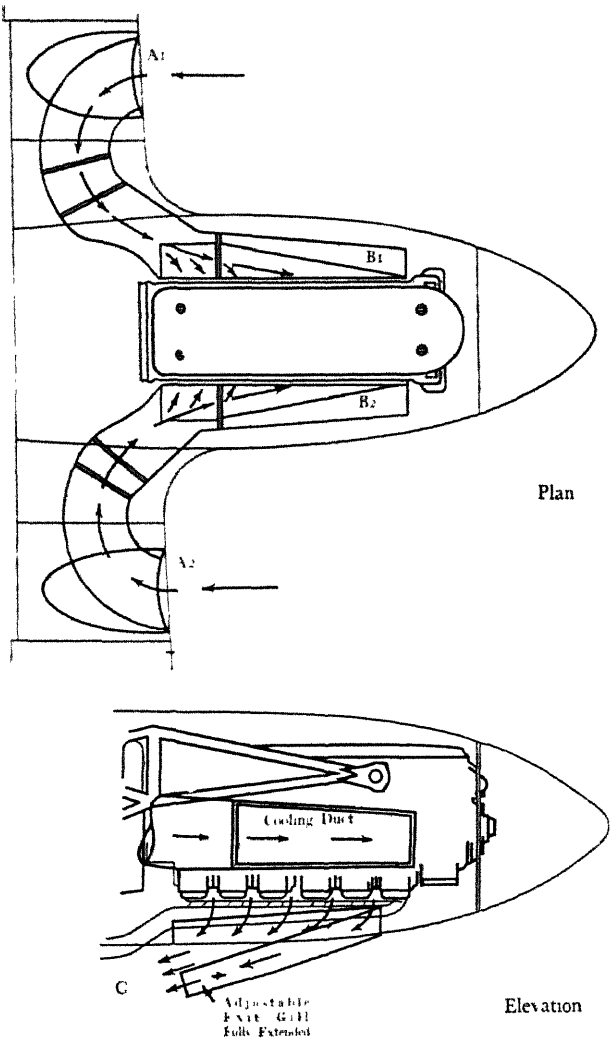

Fig. 18.—"GIPSY TWELVE" ENGINE COOLING SYSTEM

Fuel and Oil Systems

Fuel is supplied to the engine by gear-type pumps and flexible pipes of $\frac{1}{2}$-in. diameter bore. The oil delivery pipe to the engine is connected to the union in the oil suction filter unit and is $\frac{7}{8}$-in. diameter bore.

The oil return pipe from the engine is connected to the union on the supercharger jacket cover just above the carburettor and also has a bore of $\frac{7}{8}$ in.

Starting and Running

Before starting the engine for the first time, it is advisable to check the following points :

Oil is injected into the cylinders for the purpose of storing, and before starting this oil should be drained out of the exhaust ports by turning the crankshaft so that each exhaust valve is allowed to remain open for a short period of time.

Ensure that sufficient fuel is in the tank.

Check the level of the oil in the oil tank and valve-rocker covers.

Check the magneto L.T. wires and switches for continuity, correct connections, etc. This check can be made by using an electric torch or hand lamp in the circuit. On completion of these tests, ensure that switches are "off."

Check over the tightness and locking of all bolts and nuts on the engine and mountings.

Operate all engine controls to check full movement at engine end.

Check connections on the oil-pressure gauge pipe and revolution indicator.

Examine the cowling and ensure that draw wires are locked.

Check for leaks in the fuel system by operating the fuel pumps until the normal pressure registers on the gauge.

Turn the engine by means of the airscrew to check clearance between spinner and cowling.

In extremely cold weather the oil should be warmed before any attempt is made to start the engine.

Cold Starting

Move airscrew control into the "coarse pitch" position. Check that air intake is in the "cold" position. Place the mixture control in the "ultra rich" or "starting" position, and open the throttle slightly. Give the engine four or five strokes with the doper, and press the starter button, at the same time set the switches to the "on" position. Do not operate the throttle while starting, as this will result in fuel being pumped into the induction system.

Move the mixture control to "rich auto" position. When full engine oil pressure registers, move airscrew control to "fine pitch" position. This will allow warm oil to enter the airscrew. The engine may now be warmed up for power and magneto checks.

Hot Starting

Place mixture control in "rich auto" position, give engine about two strokes with the doper, and press the starter button after switching "on."

Running Up and Check

When the oil inlet temperature reaches 25° C. or over, the engine can be opened up.

In cold weather it is permissible to run up on "hot-air intake."

The airscrew control should be operated in order to promote circulation of oil in the airscrew.

The static r.p.m. should be 2,550, within 25 r.p.m. either way, with the airscrew in fully fine pitch.

At this r.p.m. the boost should be 3½ lb. per square inch. Each switch should be switched off in turn to check the magneto drop, which should be 50 r.p.m.

The fuel pressure should read 1½ to 2½ lb. per square inch. The oil pressure on first starting will be 90 lbs./sq. in. falling to 60 to 65 lbs./sq. in. under normal operating conditions.

Possible Causes of Failure to Start

(1) *In Hot Weather, Mixture too Rich.*—If this is the case, open the throttle and motor the engine for several revolutions with switches "off."

A booster coil is fitted in circuit with the starter switches; therefore, under these circumstances the engine will tend to fire, even though the main switches are "off."

(2) *Water or Foreign Matter in Carburettor.*—Remove cover beneath jets, and flush carburettor through by operating the fuel pump; then replace cover.

(3) *Booster Coil not Functioning.*—Remove cover, clean points, and adjust so that points are just touching, and give one further half-turn inwards and lock. On no account give more than one complete turn.

(4) *Contact-breaker Rocker Arm Stuck Open.*—This may be due to a weak or broken contact-breaker spring or tightness of the contact-breaker, rocker-arm bush.

Lightly lubricate the bush before reassembly.

(5) *Sparking Plug Oiled Up.*—Remove and clean.

Possible Troubles

(1) *Misfiring.*—Probably due to faulty or dirty sparking plug.

Locate the defective plug, remove, and clean. Examine internal insulation.

(2) *Engine Missing on One Magneto.*—Check and test all plugs and magnetos. If the trouble is located in a magneto and the fault cannot be rectified, the magneto should be removed and replaced.

Examine the switches and low-tension wiring.

Ensure that high-tension leads are correctly connected.

(3) *Engine Cutting Out in Flight.*—Check the fuel pressure and tank meters. Ensure that switches have not been switched "off."

Test engine on separate magnetos.

(4) *Low Oil Pressure.*—May be due to air leaks or air locks in suction pipes.

To prime the oil pumps and filters, remove the connection on the oil sump and prime with a syringe.

The filters may be choked or foreign matter be on relief valve seating.
Insufficient spring tension on relief valve.
Defective pressure gauge, pipe, or connection.
Lack of oil in tank.

(5) *Incorrect Fuel Pressure.*—This may be adjusted by means of the relief valve situated on the fuel pump, and is revealed by removing the large dome nut.

(6) *Defective Boost Pressure.*—Check the boost gauge.

Check the throttle control for full operation and range.

Check the connections on the boost pressure pipes. Fault may be found in the diaphragms of the boost control unit on the carburettor, and these should be examined periodically.

Rough Running

(1) *Tappets require Adjusting.*—Reset to the normal clearance of 0·005 in. for inlet and exhaust.

(2) *Sparking Plugs badly Adjusted or Dirty.*—Clean, reset the gaps to 0·012 to 0·015 in., and test under pressure before replacing.

(3) *Magneto Contact Breakers Dirty or Incorrectly Adjusted.*—Clean and adjust to 0·011 to 0·013 in. with contact breakers fully advanced.

(4) Check the engine mountings for tightness of bolts, etc.

(5) *Compressions Uneven.*—Should the compression of any cylinder be weak, check the tappet clearance, and if necessary remove the head and cylinder to investigate the cause. The piston rings may be stuck, valves leaking, or joint washers may be defective.

To Stop the Engine

Before shutting down, the airscrew control should be moved into coarse pitch.

Pull the throttle back fully, turn mixture control lever to "Slow running cut-off" position, and switch off.

Turn the fuel cocks "off."

Leave the throttle in the fully closed position.

THE "GIPSY MAJOR" SERIES II ENGINE

OPERATION, INSTALLATION, RUNNING, AND MAINTENANCE

THE "Gipsy Major" Series II aero engine is an air-cooled, in-line engine, with its four cylinders inverted. The principal components are described briefly in the following paragraphs, together with notes on overhaul and general maintenance. Those operations, involving the use of special tools, should not be attempted with makeshift appliances; the tools provided in the flight and complete overhaul kits should be used.

Note.—Owing to misunderstandings having arisen due to the expressions "Top Dead Centre" and "Bottom Dead Centre" on the inverted type of engine, these positions are now referred to as "Inner Dead Centre" (piston farthest from cylinder head) and "Outer Dead Centre" (piston nearest to cylinder head).

Cylinder Head

This is an aluminium-alloy casting, which is held to the cylinder barrel by four high-tensile steel studs screwed at their upper ends into the crankcase. The joint between the head and the cylinder is made by a copper asbestos washer, which fits into a recess in the cylinder head. Flanged bronze guides are fitted for one inlet and one exhaust valve, the high-expansion steel seatings being shrunk and peened into position in the cylinder head. Dual ignition is provided by two 14-mm. sparking plugs, fitted one in each side of the cylinder head. The cylinder heads are provided with liberal fin area, to ensure adequate cooling when the engine is installed in the aeroplane. The inlet and exhaust ports are arranged on the right-hand side of the engine.

Cylinder

This is a carbon-steel forging, machined externally to form cooling fins and ground internally, special attention being directed to the graduation of wall thickness and depth of finning in order that distortion may be avoided and an even cooling effect obtained. An intermediate flange is formed on the barrel, together with spigots at either end. One spigot fits into the crankcase to the extent of the flange on the barrel, an oiltight joint being formed by compressing a Dermatine ring between the radius of

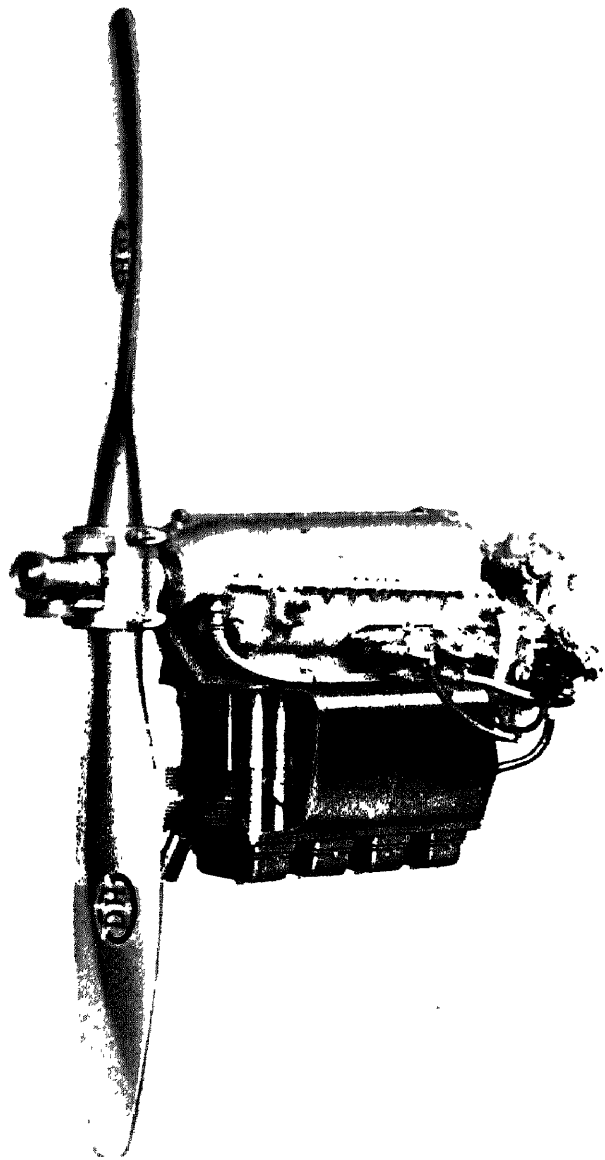

Fig. 1.—THE "GIPSY MAJOR" SERIES II ENGINE

LEADING PARTICULARS OF THE "GIPSY MAJOR" SERIES II ENGINE

Four cylinder in line, inverted, air-cooled, direct drive, dry sump.

Numbering of cylinders:	Airscrew 1, 2, 3, 4.
Firing order:	1, 3, 4, 2.
Bore:	118 mm. (4·646 in.).
Stroke:	140 mm. (5·512 in.).
Compression ratio:	6 to 1.
Direction of rotation of airscrew:	Left-hand tractor.
Crank-shaft r.p.m. international:	2,400 r.p.m.

Rated Power

At International r.p.m.:	132 138 B.H.P.

Boost Pressure

Maximum for take-off:	Full throttle.
Maximum for climbing flight:	Full throttle.
Maximum for "all-out" level flight (5 mins. limit):	Full throttle.
Maximum recommended for continuous cruising:	Minus 3 lb. per sq. inch.
Maximum control setting for economical cruising:	Weakest mixture for maximum power.

Revolutions R.P.M.

Maximum for take-off:	2,400
Minimum take-off at full throttle:	1,985
Maximum for climbing flight:	2,400
Maximum for "all-out" level flight (5 mins. limit):	2,400
Maximum for continuous cruising:	2,100
Maximum for economical cruising:	2,100

Lubrication

Oil consumption at normal r.p.m.:	1 to 3 pints per hour.
Normal oil pressure in flight:	40 to 45 lb. per sq. inch.
Inlet oil temperatures—climbing:	80° C.
Inlet oil temperatures—cruising:	70° C.
Inlet oil temperatures—emergency:	90° C.

Running of not more than 5 mins.

LEADING PARTICULARS OF THE "GIPSY MAJOR" SERIES II ENGINE

Continued

Ignition

Timing:	Inter-connected with throttle
Timing on full throttle	30° before outer dead centre.
Contact breaker gap	0·011–0·013 in.
Sparking plug gap:	0·012–0·015 in.

Valve Timing

Inlet-valve tappet clearance (cold):	0·005 in.
Exhaust-valve tappet clearance (cold):	0·005 in.
Inlet valve opens:	32¾° before outer dead centre.
Inlet valve closes:	82¾° after inner dead centre.
Exhaust valve opens:	79¼° before inner dead centre.
Exhaust valve closes:	36¼° after outer dead centre.

Standard Engine

Carburettor:	Claudel Hobson A.1 48 (latest type
Tachometer drive:	Single-engine speed.
Flame trap:	Amal.
Ignition:	2 unscreened B.T.H. AG 4-4 magnetos. One fitted with an impulse starter. K.L.G. V14-1 or Lodge A14-3 plugs.
Airscrew boss (fixed pitch):	Wooden airscrew.

Carburation

Fuel: Minimum Octane No. 77, containing not more than 4 c.c. of T.E.L. per gallon.

Fuel consumption climbing at 2,100 r.p.m. and full throttle near ground level, mixture in the fully rich position:	9¾–10½ gallons per hour.
Fuel consumption, cruising at 2,100 r.p.m. near ground level (approx. 95 B.H.P.), with mixture control adjusted to give weakest mixture for maximum power:	6–6½ gallons per hour.
Fuel consumption for all-out level flight at 2,400 r.p.m. and full throttle, near ground level, with mixture control in the fully rich position:	10¼–10⅝ gallons per hour.

The above figures refer to engines fitted with a conventional fixed-pitch airscrew giving 2,400 r.p.m. at full throttle in level flight, near ground level. Operators desirous of using fuel containing alcohol should first communicate with the engine manufacturers.

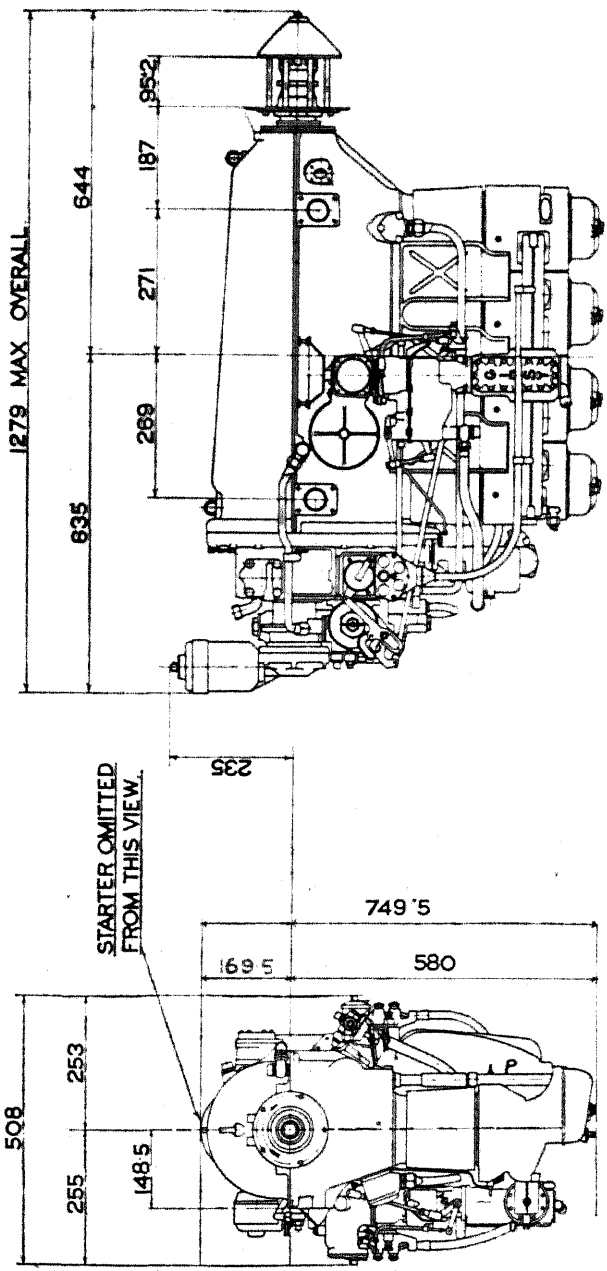

Fig. 2. PRINCIPAL DIMENSIONS OF THE "GIPSY MAJOR" SERIES II ENGINE
The dimensions are given in millimetres.

the flange and the chamfered edge of the crankcase bore.

Piston

This is machined from a forging of aluminium alloy, and is of the slipper type, so designed that the stress from the crown is taken direct to the gudgeon pin, which floats in both the piston and small end of the connecting rod, and is retained by external circlips and washers at each end. Three rings are fitted to each piston, the inner ring being of the scraper type, which scrapes surplus oil from the cylinder wall and deflects it through a series of small drilled holes, to the inside of the piston and so back to the crankcase.

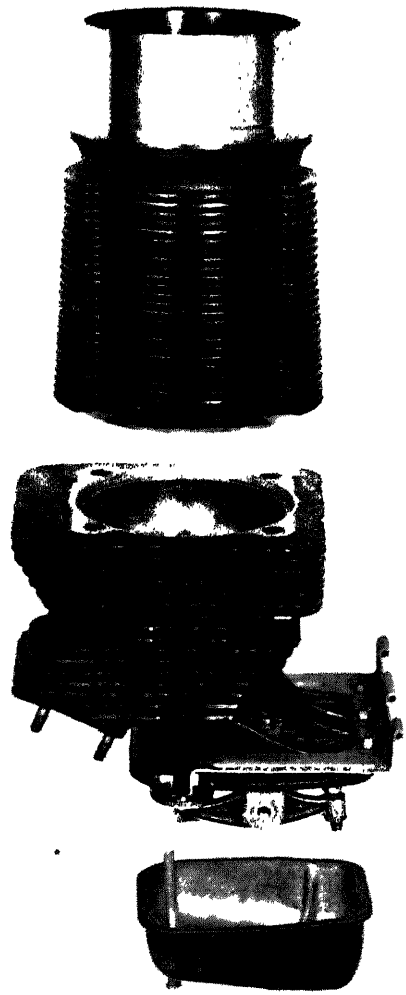

Fig. 3.—CYLINDER, CYLINDER HEAD AND ROCKER-BOX ASSEMBLY
(*de Havilland Aircraft Co., Ltd.*)

Connecting Rod

This is of D.T.D. 130 alloy forging of H section; the big end is split, and houses the steel-backed white-metal bearing which is clamped by four high-tensile steel bolts. Leak holes are provided in the cap of the rod and bearing, to distribute oil for cylinder, tappet, and camshaft lubrication. The small end is plain and unbushed, and drilled to supply oil to the gudgeon pin.

Crankshaft

This is a nickel-chrome-steel forging machined to form a five-journal crankshaft. The webs support in one plane the four crankpins, of which the centre two together oppose the outer two. The journals and crankpins are bored and capped, and the webs from No. 2 journal to Nos. 1 and 2 crankpins, and from No. 4 journal to Nos. 3 and 4 crankpins, are drilled to afford pressure-feed lubrication to the connecting-rod big ends. The front end of the crankshaft is splined for the reception of the airscrew hub, and the rear end is splined internally to take the gear operating the camshaft auxiliaries.

Airscrew Hub (Fixed Pitch)

The airscrew hub is fitted over the splined extension of the crankshaft, and centralised by means of a split steel cone and aluminium-bronze cone at front and rear respectively. When a wooden airscrew is fitted, it is centralised on the hub by means of a narrow raised land, which is situated on the centre line of the airscrew. This narrow centralising land is used to overcome splitting of the airscrew boss, which can occur if a wooden airscrew contracts on to its hub. When a metal fixed-pitch airscrew is fitted, a hub can be supplied on which there is no narrow land as described above, the airscrew fitting over and centralising on to the hub in the usual manner.

The front plate is splined to the central hub of the airscrew boss; therefore, being positively driven, the eight bolts are relieved of unnecessary stress.

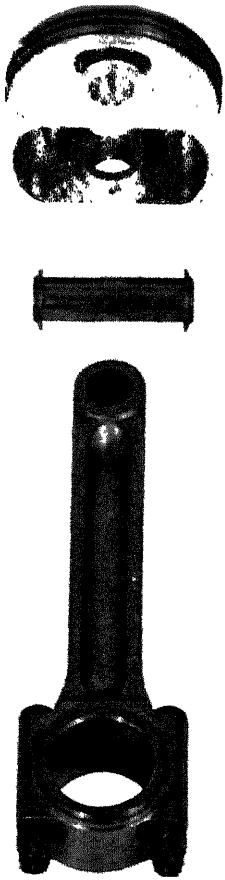

Fig. 4.—PISTON, GUDGEON PIN, AND CONNECTING-ROD ASSEMBLY
(*de Havilland Aircraft Co., Ltd.*)

Crankcase and Top Cover

The crankcase is a deep-section casting of magnesium alloy. The front wall and tapered section between them carry the housing for the long, front main bearing. The rear bearing housing is carried by the rear wall of the crankcase. Each of the intermediate bearings are held by

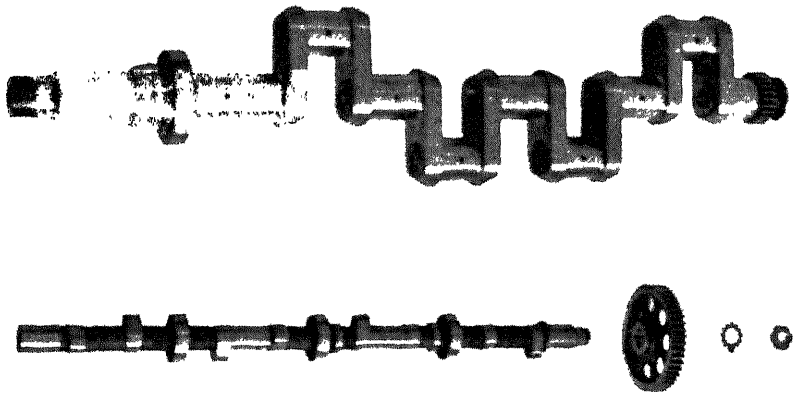

*Fig. 5.—*CRANKSHAFT AND CAMSHAFT
(by Havilland Aircraft Co., Ltd.)

separate caps, thus facilitating assembly, overhaul, and inspection, as none of these bearings need be disturbed when the crankcase top cover is removed. The protrusion of the cylinder barrels converts the lower part of the crankcase into a sump, holes in the cross webs permitting the oil to flow to front or rear of the engine, where drain outlets, provided in the right-hand side wall of the crankcase opposite No. 1 cylinder and in the base of the rear cover respectively, enable the surplus oil to be returned to the tank. A facing is provided at crankshaft centre level, to which the crankcase top cover is attached by bolts. This top cover is bored at the front end in conjunction with the crankcase to form a housing for the special-type thrust ball bearing, the rear end is faced vertically to take the rear cover, while internal transverse webs assist stiffening.

Camshaft

This is of steel, with eight integral cams, and is borne in bearings in the lower part of the crankcase on the left-hand side. The three intermediate journals run in bearings bored directly in the cross webs of the crankcase, and are of large diameter to enable the camshaft to be withdrawn to the rear. The front and rear bearings are aluminium alloy and magnesium alloy respectively, and are bolted to the crankcase. The bearings are lubricated by oil mist and holes drilled in crankcase. The spur wheel driving the camshaft is vernier keyed to the extreme rear end and secured by a nut and tabwasher.

Valve-operating Gear

Each cam operates a sliding tappet, which lifts the valve by means of the usual tappet rod and rocker mechanism, the closing of the valve and the return stroke of the tappet being accomplished by the action of the valve springs. The tappet is square ended at the cam end to prevent rotation and is bored from the other end for the greater part of its length, also through the side at the square end, and fitted with a ball to engage the tappet rod. The tappet reciprocates in a flanged guide housed in the crankcase, and bolted to the lower face thereof. The tappet rod is of D.T.D. 130, fitted at the upper and lower ends with a cup and ball end respectively. The steel rocker, which has a phosphor-bronze bush, pivots about its offset centre on a hardened-steel spindle, which is held in a stamped-steel bracket.

At the push-rod end, the rocker is tapped to receive a hardened-steel screwed cup end and locknut, by means of which tappet clearance is adjusted. The other end of the rocker is fitted with a riveted-in hardened-steel pad. A telescopic cover encloses the tappet rod and seats outwardly under the action of an enclosed central spring, against a Dermatine ring in the tappet-guide flange at the crankcase and a Dermatine ring in a facing on the top side of the cylinder head. The valves, rockets, etc., are completely enclosed by a cast elektron box, held in position on the underside of the cylinder head by a cap nut.

Valves

The valves are of steel, the exhaust being Hadfield's New Era D.T.D. 49A and the inlet S62. The exhaust valve seat is stellited, a process which is found to be essential when running engines on a fuel containing a certain tetra-ethyl lead content. The ends of both the exhaust and inlet valve stems are also stellited in order to withstand wear. Both valves have tulip-shaped heads, the head of the inlet being slightly larger in diameter. Double concentric valve springs are fitted between the flange of the guide and the valve-stem collar, which in turn is held in position on the valve with split taper collets.

Timing Gears

These are housed in the rear cover, which is held by studs and nuts to facings provided at the rear of the crankcase and top cover. The gear fitted to the rear end of the crankshaft meshes with the two spur wheels situated one above and the other below the centre line of the crankshaft. The upper spur wheel drives a short shaft, which has fitted to it a bevel gear, which in turn drives, by means of two more bevel gears, the Eclipse vacuum air pump on the left-hand side of the rear cover and the governor for the constant-speed type of airscrew on the right-hand side. The lower spur wheel drives the camshaft, and in conjunction with the vernier enables the valve timing to be adjusted.

The gear oil pump is bolted to a facing on the lower part of the rear cover and carries a spur gear which meshes with the camshaft gear. Bolted to an extension of the intermediate gear is a skew gear, which drives a similar gear mounted on a short transverse shaft below. This shaft, the ends of which are mounted in ball bearings housed in the sides of the rear cover, has a flexible vernier coupling fitted to each end to drive a magneto.

The magnetos are bolted on external brackets which are part of the rear cover, and are arranged so that the contact breakers and distributors point outwards, thus permitting easy adjustment and inspection. The right hand side magneto is fitted with an impulse starter which delivers a powerful spark at low engine revolutions and thereby facilitates starting.

Induction System

A square-section welded-steel manifold is bolted to the inlet-port facings on the cylinder heads. The main trunk runs upwards from the manifold and finishes with a welded flange, to which is bolted the carburettor. The trunk and central portion of the manifold have a square-section jacket welded on. Two connections are provided at the base of this jacket, and exhaust gas is fed in from the front of the exhaust system. The inside of the jacket is baffled to ensure that the maximum amount of heat is extracted from the gas, before it is allowed to escape through the outlet connection. The down-draught carburettor is a Hobson Type AI.48 (latest type), and is provided with a mixture control for correcting fuel mixture at altitude or when cruising. The air for combustion is drawn into the carburettor through a special air intake designed to avoid all freezing troubles without adverse effects as regards maximum power. Under normal cruising conditions, when freezing is most likely to occur, hot air is taken from the vicinity of the cylinders and led through a flame trap direct to the carburettor. In this way a nicely warmed induction is obtained, resulting in excellent smoothness and economy of operation. When, however, maximum output is required, the resistance of a flame trap and a high-induction temperature would somewhat reduce the horse-power obtainable.

Under these circumstances, therefore, a throttle-operated valve closes communication between the flame trap and the carburettor, and at the same time opens a duct communicating with the slipstream through a normal external type of carburettor air intake.

Lubrication

The oil pumps and filters form detachable units bolted on the rear cover. A gear-type pump draws oil from a separate tank and delivers it under pressure to an " Auto Klean " filter, which ensures the removal of the finest particles of foreign matter before passing the oil into the engine.

A fine-gauze filter protects the suction side of the pressure pump, while the main oil pressure is regulated to 40–45 lb. per square inch by a relief valve. From the pressure filter the oil is forced to the main oil gallery which is fitted to the inside of the crankcase. This gallery admits oil to the five main bearings. From the main bearings Nos. 1 and 4, oil is forced through the journals and adjacent webs into the hollow crankpins which supply the big-end bearings. Holes are drilled in the big-end bearings and connecting-rod caps, from which oil is thrown on to the cylinder walls and pistons. This arrangement is particularly useful on starting, as proper lubrication of the pistons is established during the first revolutions of the engine; moreover, the supply of lubricant to the cylinder walls is not affected to a large extent by wear of the bearings.

The spray thus created inside the crankcase serves to lubricate the cams and tappets, and as a good deal of it ultimately comes into contact with the walls of the top cover, a useful cooling effect is obtained; after passing through the engine, the oil collects in the space formed by the extension of the cylinders inside the crankcase. Oil is collected at the front of the engine, is scavenged by means of the second scavenge pump, via an external steel oil pipe, from a cast elektron filter box bolted to the front end of the crankcase. The oil collected at the rear of the engine drains through a hole in the front face of the rear cover to an external vertical "settling tank," from which it is drawn by the first scavenge pump and so back to the tank. These pumps are arranged in tandem with the pressure pump, and are provided with a detachable suction filter of fine-mesh gauze. In the pressure-filter casing, connections are provided for two pipes, the upper one of which supplies oil to the revolution indicator drive shaft bushes and thence to a jet which delivers on the pitch of the magneto drive skew gears, and the other to the oil-pressure gauge. The magnetos fitted are of the ball-bearing type, the bearings of both armature and distributor spindles being packed with high melting-point grease, sufficient to last 750 hours' flying. A frequent application of anti-freezing oil should be given to the impulse-starter mechanism through the hole in the side of the casing.

Oil Filters

The oil filters are contained in elektron castings attached to the rear of the rear cover by studs and nuts. The vertical filter is installed on the suction pipe line, and the horizontal filter on the pressure side of the oil pump.

The filters are accessible for cleaning by unscrewing the large hexagonal caps. As the pressure filter is of the "Auto Klean" type, it is only necessary to dismantle the filter for cleaning after every 250 hours' flying. The tommy bar, however, should be turned frequently in order to clear the filter.

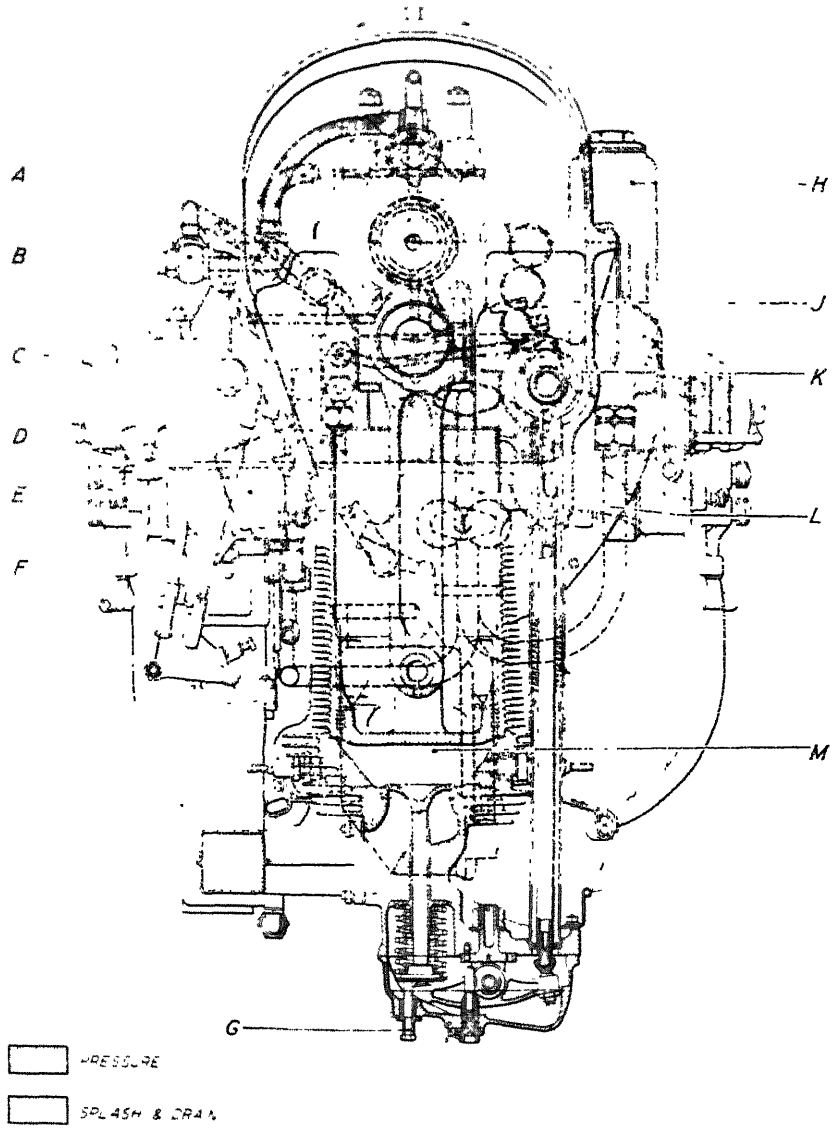

Fig. 6. - Lubrication diagram for "Gipsy Major" Series II Engine (front view)

A, Pressure oil feed to air-screw governor facing or cover plate and vacuum pump facing and drive; B, Pressure oil feed to crankshaft main bearings and connecting-rod bearings; C, Pressure oil feed to tachometer drive and timing-gear oil jet; D, Connection to pressure gauge; E, Front oil drain; F, Return oil drain; G, Vent pipe; H, Oil suction filter; J, Timing-gear oil jet; K, Pressure oil filter; L, Oil pump; M, Settling tank.

INSTALLATION

Engine Mounting

Four vertical facings are provided on the sides of the crankcase for the attachment of the engine feet. A turned recess is provided in each of these facings, and the engine foot spigot fits into this recess so that the shear load is taken off the four studs provided for fixing the engine feet. The feet are arranged for a trunnion fixing, and should be mounted in the "D"-shaped rubber blocks which the de Havilland Aircraft Co., Ltd., can supply on application. The red rubber blocks as fitted to the engine feet are for transport purposes only, and on no account must be used in the aeroplane installation.

Cooling System

The engine will normally be enclosed by the nose cowling when installed in the aeroplane, the cooling of the engine has therefore to be arranged by special scoops and baffles. The standard airscoop supplied is fitted on the left-hand side of the engine beneath the aeroplane cowling. The airscoop is attached by hinge pins to plate extensions on the top of the valve-rocker casings and the base of the crankcase respectively. The scoop is bowed, and slopes towards the cylinders to the rear, its distance therefrom decreasing slightly from front to rear.

Baffle plates are fitted to the cylinders on the right-hand side of the engine, in order to deflect the air around the lee side of the cylinder barrels and so obtain the maximum amount of cooling. The baffles are attached by a hinge pin to a bracket on the crankcase and to clips under the cylinder holding-down nuts. It should be noted here that the cooling system should be such that the maximum cylinder-head temperature measured on the climb should not exceed 220° C.

Fuel System

The joints of the fuel pipe between the aeroplane and the engine can be made by A.M.-type metal couplings or brazed nipples and union nuts. Where the fuel pipe crosses from the aeroplane structure to fuel pump or carburettor, a flexible pipe, such as "Superflexit," must be used. All pipes, filters, and cocks should have a clear bore of not less than $\frac{3}{8}$-in. diameter. Where rigid fuel pipes are used, these should be well supported, so that no vibration is set up caused by their own weight. Under no circumstances should the depression on the inlet side of the fuel pump, caused by restriction or low fuel tank position, exceed $1\frac{1}{2}$ lb. Should this figure be exceeded, troubles will probably be experienced by gas locking in the fuel pumps. The amount of depression which can be put on the fuel before the formation of gas commences is affected by temperature, altitude, and the vapour pressure of the fuel.

Should it be intended to operate the aeroplane under conditions which

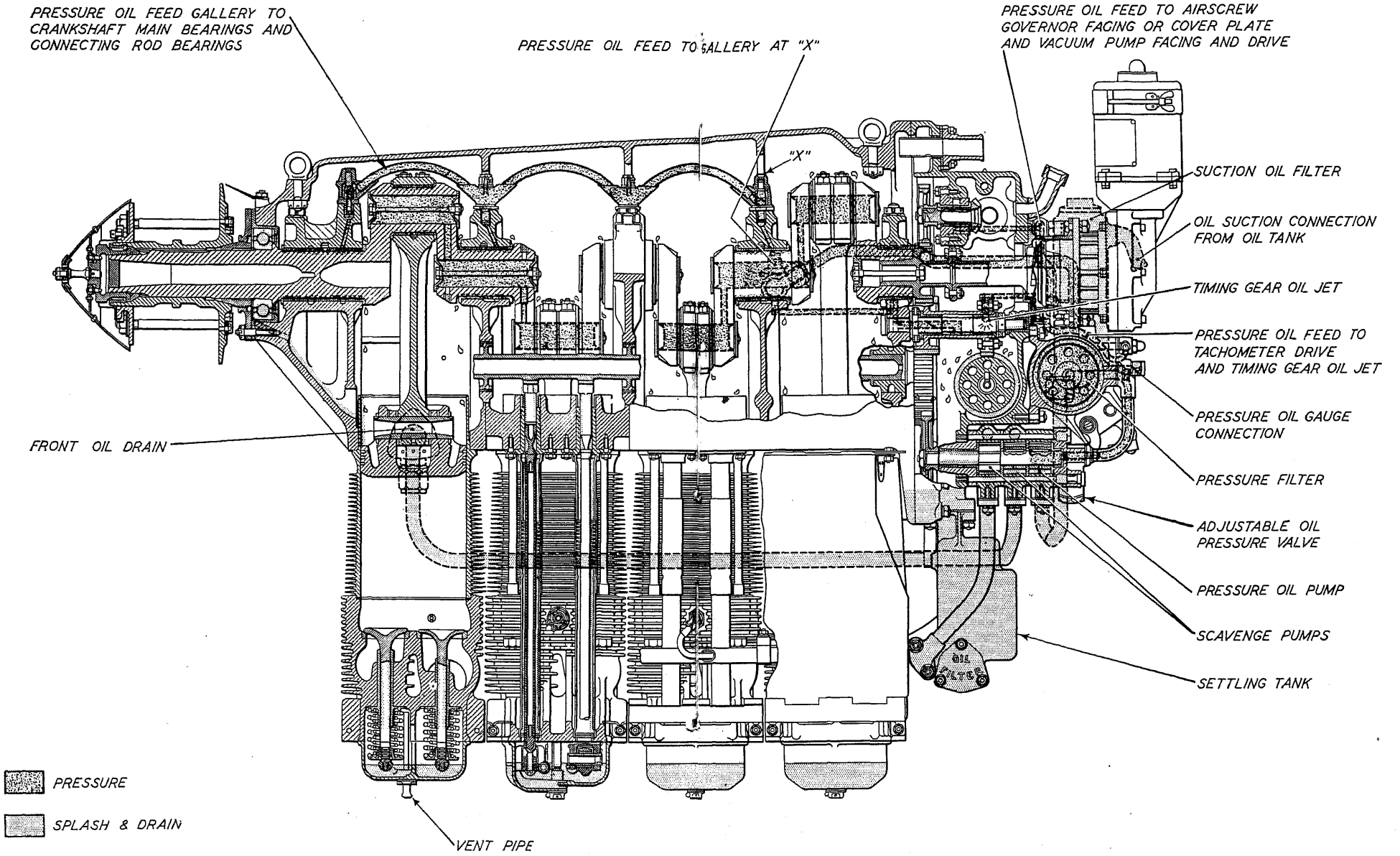

Fig. 7.—Lubrication diagram of de Havilland "Gipsy Major" Series II Engine (side view)

tend to the formation of gas, depression on the fuel-pump inlet should be kept to the absolute minimum, even less than the figure quoted above, if at all possible.

D. H. A.C. Petrol Pump

The pumps deliver the fuel directly to the carburettor, and no reserve supply is necessary. The supply pipe from the tanks should be connected to the suction side of the pumps. Special precautions are necessary when fitting the suction piping on installations using fuel pumps, as air leaks, which are difficult to detect, are a possible cause of engine failure.

Ignition System

The earthing terminals on the magneto contact-breaker covers should be connected up to a standard twin-knob switch, and labelled to enable the magnetos to be earthed independently as required. The common earth connection on the switch is wired directly to some part of the engine and not to the airframe : this is important. To ensure safety to personnel when starting the engine by swinging the airscrew, check the L.T. earthing wires for continuity occasionally, using, if available, the standard magneto synchroniser as a continuity tester. Alternatively the check can be made by using an electric torch or hand lamp with a length of flex connecting from the earthing spring on the magneto to the switch at the cockpit. Removal of the magneto contact-breaker covers will be necessary, which renders the earthing switches inoperative. This is dangerous, as action of the impulse starter may start the engine should the airscrew be turned. *In no circumstances should these tests be made without either* (*a*) *disconnecting all the H.T. leads from the sparking plugs, or* (*b*) *removing the distributors from the magnetos.* After completing the test, leave both switches in the " off " position.

Oil System

A nut and nipple for the attachment of a pipe leading to the 0–60 lbs./sq. in. pressure gauge, or alternatively, a post suitable for the fitting of a Negretti and Zambra transmitting oil-pressure gauge, is provided on the pressure-oil filter casing. When a nut and nipple is used, an approved gauze-covered petrol-resisting rubber connection should be provided on the pipe as close as possible to the fitting on the gallery, to take up vibration. This type of connection is preferable to a coiled pipe, as the coils are liable to vibration trouble, due to their own weight.

The oil delivery pipe to the engine is connected to the top elbow in the oil suction filter unit, using a P.R. rubber connection ; this pipe should be at least $\frac{7}{8}$-in. diameter bore. The oil return pipe from the engine is connected to the $\frac{5}{8}$-in. outside diameter hose connection situated below, and slightly to the right hand of the oil-pump unit, using a P.R. rubber connection, the pipe being at least $\frac{5}{8}$-in. diameter bore. A 1-in.

diameter hose connection is attached to the rear of the rear cover to which the breather pipe must be attached. Directly below the above mentioned is a $\frac{5}{8}$-in. outside diameter brass hose connection, which must be connected to the air space above the oil in the tank. When this connection is not used, a small blanking cover is fitted in its place.

As the engine is equipped with dual scavenge pumps, the position of the oil tank is comparatively unimportant. Should the oil tank be very much above the oil inlet level, it may be necessary to provide a cock which can be shut off when the engine is standing to stop oil from draining from the tank to engine. This cock should be interconnected to the fuel cock, to avoid the possibility of the engine being run with the oil cock off. Provision can be made, in the inlet and outlet pipes to and from the engine respectively, for the usual oil thermometer pockets, which must be fitted within 10 in. of the engine itself.

Engine Controls

Engine control levers in the cockpit should be connected up to the pick-up levers provided on the left-hand side of the engine cross shafts, or to pulleys should the aeroplane be fitted with pulley-operated throttle and mixture controls. It is important that the controls in the cockpit give slightly more than sufficient movement in order to give full travel to the controls on the engine ; this will ensure that the controls will be brought up positively against the stops on the carburettor. The throttle and magneto controls are interconnected in such a way that when the throttle is closed, the ignition is fully retarded. As the throttle travels through the first part of its movement, the ignition is fully advanced, where it stays throughout the whole of the cruising range. When a de Havilland two-pitch airscrew is fitted, a control must be fitted up between the cockpit and the oil-cock operating lever, at the rear of the oil-pump casing. If a constant-speed airscrew is fitted, a control must be fitted up between the pulley on the governor and the cockpit.

Storage

Engines not required for immediate use should be stored with cylinders upwards and maintained by frequent oiling through the sparking-plug holes and turning of the crankshaft.

STARTING AND RUNNING

Before Starting

Before starting the engine for the first time, it is advisable to check the following points :

(1) Ensure that all oil injected into the cylinders for the purpose of storing is allowed to drain out of the exhaust ports by turning the crankshaft, so that each exhaust valve is allowed to stand open for a short period.

(2) See that sufficient fuel is in the tank.

(3) See that sufficient oil is in the tank and valve-rocker covers.

(4) Check the magneto L.T. earthing brushes, wires, and switches for continuity, correct connections and functioning by using the standard magneto synchroniser as a continuity tester. Alternatively, the check can be made by using an electric torch or hand lamp with a length of flex connecting from the earthing spring on the magneto to the switch at the cockpit. Removal of the magneto contact-breaker covers will be necessary, which renders the earthing switches inoperative. This is dangerous, as action of the impulse starter may start the engine should the airscrew be turned. *In no circumstances should these tests be made without either (a) disconnecting all the H.T. leads from the sparking plugs, or (b) removing the distributors from the magnetos.* After completing the tests, leave both switches in the " off " position.

(5) Check over the tightness and locking of all bolts, nuts, etc., on the engine and mountings.

(6) Operate all engine controls to see that these work freely, and give full movement to the throttle, magnetos, etc.

(7) Check the connection of the oil-pressure gauge pipe.

(8) Check the connections of the revolution indicator.

(9) Check all cowlings and fixings and locking of draw wires, etc.

(10) Turn on fuel and check for leaks.

(11) Turn the engine over to check the clearance between the airscrew spinner and cowling.

(12) Check the position of the impulse break. The audible click given by this mechanism should take place when the airscrew blade is between 30° and 45° before the lower vertical position. If the engine is fitted with hand starting gear, the position of the impulse break in relation to the airscrew is not of importance.

(13) Prime suction oil filter.

Starting

Note.—During arctic weather conditions, no attempt should be made to start the engine until the oil has been warmed.

Starting by Swinging the Airscrew

See that both magneto switches are " off." Flood the carburettor by depressing the spring plunger provided in the top section of the float chamber of the carburettor.

The fuel-pump priming levers will have to be operated while the spring plunger on the carburettor is depressed by means of the small wire led to the port side of the engine. Open the throttle very slightly, and pull the engine over not more than four or five compressions. Increase the opening of the throttle slightly, after putting the right-hand or impulse magneto switch in the " on " position ; pull the airscrew sharply over

compression. The engine should then start. If the weather is hot, do not pull the airscrew over to suck in, but flood the carburettor slightly, and start at once. If the engine is hot, do not flood the carburettor at all, as the mixture under these conditions may easily become too rich.

Starting with an Electric Starter

The same instructions as given in "Starting by Swinging the Airscrew" can be generally applied. In this case, however, instead of pulling over four or five compressions, motor the engine for a few revolutions.

Starting with a Hand-starting Gear

The same instructions as given in "Starting by Swinging the Airscrew" can be generally applied. In this case, however, instead of pulling over four or five compressions, turn the engine for a few revolutions.

After Starting

If oil pressure does not show between 30 and 40 lb. per square inch within one minute, shut down engine and investigate cause. Possible causes are: air leaks in suction oil pipe, or suction filter connections; pump requires priming; defective oil-pressure gauge, or choked pipe to gauge. When oil pressure is at figures given, run engine at 800–900 r.p.m. for at least four minutes to allow the oil to warm up and circulate freely. The oil temperature will probably not show on the thermometer, but it may be assumed that, after this run, the oil temperature and circulation are satisfactory, and the engine can be opened up to full throttle to ascertain the ground r.p.m. The running of the engine at full throttle on the ground must be carried out with a certain amount of discretion, and under no circumstances should the full throttle running exceed a period of 30 seconds, or less in tropical climates.

It should be observed that this full-throttle running is only for the purpose of obtaining the ground r.p.m. and not for the purpose of warming up.

The running of the engine should be checked on each magneto. Revolutions per minute will probably drop slightly, but the engine should run smoothly and evenly on each magneto. Check magnetos with engine running between 1,600 r.p.m. and full throttle.

Oil pressure under these conditions should be between 40–45 lb. per square inch. Revolutions on the ground will vary with the different airscrews fitted, but will probably be between 1,900 and 2,050 per minute with a fixed-pitch airscrew.

Possible Causes of Failure to Start

(1) Cold or hot weather. In cold weather it is almost impossible to get the mixture too rich. In hot weather, too rich a mixture is most

likely the cause of the engine not starting. If this is the case, open the throttle wide, and motor the engine over for several revolutions, with the switches " off."

This will clear the engine, which should then be started by following the instructions in paragraph " Starting."

(2) Carburettor slow-running jet choked.

(3) Water in the carburettor. Remove the main and power jets, and flush the carburettor through by turning the fuel cock " on."

(4) Impulse starter not working properly. When the engine is turned, there should be an audible click from the impulse starter on the right-hand magneto near the inner dead-centre position of any piston.

The actual arrest and rotation of the magneto armature after release can be observed by removing the right-hand magneto contact-breaker cover. The earthing switch for the magnetos will now be inoperative. This is dangerous, as action of the impulse starter may start the engine when turning the airscrew. *In no circumstances should this inspection be made without either (a) disconnecting all the H.T. leads from the sparking plugs, or (b) removing the distributors from the magnetos.*

(5) Sticking caused by end pressure exerted on the impulse-starter units, owing to swelling of the flexible vernier couplings, which may occur through oil coming into contact with the coupling. To rectify, slacken the holding-down screws of the magnetos, and ease the latter slightly away until the flexible coupling is just gripped.

(6) Non-operation of the mechanism through congealed oil or lack of lubrication. Flush out with paraffin and lubricate with anti-freezing oil. If, after making the above adjustments, failure still persists, replace the magneto with a new one.

(7) Contact-breaker rocker arm stuck open. This may be due to (*a*) a weak or broken contact-breaker spring, or (*b*) tightness of the contact-breaker rocker-arm bush. After rectifying the cause of the trouble, the bush should be very slightly lubricated before reassembly.

(8) Damp atmosphere. If the engine has been standing in a damp atmosphere, it may be necessary to wipe the insulators of the sparking plugs and the distributors of the magnetos before a start can be made to reduce the surface leakage of H.T. current, which takes place under these conditions. (When the engine is fitted with a screened ignition equipment, this does not apply.)

Possible Troubles

(1) Misfiring. Should any one cylinder misfire or cut out when running, locate the defective sparking plug and clean, or fit a new one.

(2) Engine misfiring on one magneto. Check and test all plugs and magnetos. If the trouble is traced to a magneto or distributor, and no fault can be detected which can be readily rectified, it should be returned to the manufacturers. If the engine cuts right out on one magneto,

examine the switches and low-tension wiring as well as the magneto, also ensure that the high-tension leads are connected up to their correct terminals on the magneto distributors.

(3) Engine cutting out in flight. Make sure that the switches have not been switched "off" accidentally. Test the engine on separate magnetos, as a fault in one magneto or distributor may upset the running of the engine.

(4) Low oil pressure. This may be due to air leaks, or air locks in the suction pipes, choked filters, stuck release valve, defective pressure gauge, or defective pipe line to same.

Rough Running

(1) Airscrew out of balance. If possible, check engine with a different airscrew. When a fixed-pitch airscrew is being refitted to the engine, see that the bore of the airscrew is a snug fit on the locating land of the boss. The bolts should be tightened up evenly, and the track of the blades, measured at the tips, should not differ by more than $\frac{1}{4}$ in. If a de Havilland C.P. or constant-speed airscrew is fitted, reference should be made to the appropriate instructions.

(2) Tappets out of adjustment. Reset to the standard clearances.

(3) Sparking plugs dirty or badly adjusted. Clean, reset the gaps, and test if possible, under pressure, before replacing.

(4) Magneto contact breakers dirty or incorrectly adjusted. Clean and readjust.

(5) Engine mounting or holding-down bolts loose. The rubber blocks may be incorrectly fitted.

(6) Compressions uneven. If the compression of any cylinder is very weak, first check the tappet clearance, and if necessary remove the head and cylinder, and investigate the cause; probable causes are: stuck piston rings, leaky valves, or defective head joint washers.

(7) Air leaks in induction system. Inspect and test the induction manifold for leaks. Inspect the cylinder port washers and carburettor joint washer for tightness.

Low R.P.M. on Ground

If all the parts of the engine are in order and the engine is running well, low engine r.p.m. may result from the use of an unsuitable airscrew. Another airscrew should be substituted to check this. When a de Havilland controllable-pitch airscrew is fitted, low r.p.m. may be caused by too coarse a pitch, which should be set accordingly.

Cold-weather Difficulties

Using oil of too heavy a grade. If a heavy grade of oil is in use, it will be an advantage to preheat the oil, especially if the engine has been standing out in the cold for any length of time.

DISMANTLING FOR OVERHAUL, INSPECTION AND REASSEMBLY

Removal of Fixed-pitch Airscrew and Hub

Remove the split pin and slotted nut at the front of the spinner, which will allow the spinner to be pulled off. Unscrew the four cheese-head screws and remove the locking plates. Using box spanner and tommy bar, unscrew the crankshaft front nut. As this nut is unscrewed, the aluminium-bronze cone at the front of the boss will be pulled forward up against the withdrawal nut, so pulling the hub together with the air-screw, from the splines of the crankshaft.

Removal of Controllable-pitch and Constant-speed Airscrews

If a de Havilland controllable-pitch or constant-speed airscrew is fitted, it must be removed in accordance with the appropriate instructions.

Removal of Engine from Aeroplane

Remove cowling, cold-air intake, disconnect fuel pipes, oil pipes, engine controls; remove exhaust manifold, using special spanner. Disconnect revolution indicator drive, breather pipe, and remove caps which hold engine-foot mounting blocks. If an electric starter is fitted, remove leads from starter, and if necessary to clear aeroplane structure, when engine is being lifted out, remove starter itself by unscrewing the six retaining nuts. The engine should now be slung by the two eyebolts in the top cover, and with engine still on the sling, if available, fit engine feet which are more suitable for bolting to the workshop engine stand, and which preferably should be of the type suitable for inverting the engine. Remove locking wires, nuts, and valve-gear covers which contain oil, and then invert engine.

Removal of Induction Manifold and Ignition Equipment

Remove induction pipe, carburettor, and hot-air intake complete as one unit, using universal spanner to remove nuts holding induction pipe to cylinder heads. Remove distributors with high-tension leads by unscrewing the four retaining nuts. Remove cylinder baffles, then sparking plugs, using box spanner and tommy bar.

Removal of Rocker Spindles, Rockers, and Tappet Rods

(1) Remove the clamping bolts holding the valve-rocker spindles in place in the rocker brackets and, using extractor, withdraw rocker spindles.

(2) The rockers and tappet rods may now be removed.

(3) Telescope the two halves of the tappet-rod casing-tube together, and remove from position.

Removal of Cylinder Heads and Barrels

Loosen all cylinder-head nuts. Ease cylinder heads up, as these are being unscrewed, and remove cylinder baffle brackets and nuts. Lift cylinder head clear of studs. Next remove cylinders. These should be eased carefully with pistons on outer dead centre, supporting the pistons as cylinders are lifted clear ; should the cylinders be stuck in the crankcase, striking them sideways alternately with the palm of the hand should loosen them.

Removal of Pistons

Remove circlips from one end of each gudgeon pin, using the circlip extractor. Care should be taken to avoid damaging or burring groove or slot at end of the gudgeon pin during this operation. If a burr is accidentally raised, stone it off to prevent scoring of the bore in the piston boss and connecting-rod small end, during removal of the gudgeon pin. After removal of the washers, the gudgeon pin can be pushed out and the piston removed. If the gudgeon pin is too tight to be removed by hand, it should be extracted by using gudgeon-pin extractor.

Removal of Rear Cover

Remove engine controls and external oil pipes connecting the rear cover to the crankcase. Unscrew the nuts which secure the rear cover to the crankcase and also the bolt placed behind the oil-pump outlet to tank. Tap the cover all round with a rubber mallet in order to break the joint and draw cover towards the rear.

Owing to gear tending to foul on the inside, it will be necessary to ease the rear cover slightly to the left-hand side, immediately it is clear of the studs. It will be found that the rear cover, oil pumps, magnetos, starter (if fitted), etc., can now be removed as one unit.

Removal of Camshaft Gear, Front Cover and Thrust Race

Bend the tab back out of the slot in the nut at the rear of camshaft and unscrew nut. Using extractor, pull off the camshaft gear. To remove the steel front cover, first remove the split pins and then unscrew the five retaining nuts, which will allow the front cover to be drawn off its studs. The thrust-race housing, together with the thrust race, oil flinger, and bronze cone, is now withdrawn, using extractor bolts in the holes provided. While carrying out this operation, great care must be exercised to ensure that the thrust-race housing is not distorted, as the rear cone is a tight fit on the shaft. Now remove all nuts and spring washers holding the tappet guides in place.

Removal of Top Cover and Crankshaft Assembly

Remove the bolts, plain nuts, and spring washers which hold the top cover to the crankcase, and after breaking the joint by lightly tapping

all round, lift off the top cover. Remove the nuts and copper and asbestos washers, then lift off the oil gallery. Bend back the locking tabs and unscrew the castellated nuts holding the main-bearing caps in position. Remove the main-bearing caps complete with bearings. Lift the crankshaft complete with connecting rods from the crankcase. Remove the half-bearings from the crankcase.

Removal of Camshaft and Tappets

It will be found better to remove the tappets from the crankcase before attempting to remove the camshaft. After removing the tappet-guide retaining nuts and spring washers, the complete tappet can be tapped out of its cover. A fibre drift is recommended for this operation. Next remove the three plain nuts and spring washers holding the camshaft front bearing, which should be removed by using the drift and tommy bar. Then remove the two split pins, slotted nuts and washers holding the rear camshaft bearing in the crankcase. The camshaft may then be withdrawn towards the rear, together with the rear bearing, care being taken that the intermediate camshaft bearings are not damaged.

Dismantling of Crankshaft Assembly

Remove the split pins, castellated nuts, and thin steel washers on the connecting-rod bolts. Tap back the bolts with a soft drift until they are clear of the caps. Lift off the caps and half-bearings, and lower the rods off the shaft. Remove the split pins and slotted nuts from the bolts in the crankshaft oil seals. Remove the bolts, seals, and copper and asbestos washers. Remove split pin and nut on the retaining bolt, holding the crankshaft gear. Remove the retaining bolt. To extract the gear, use the extractor. Place the sleeve of the puller over the gear, and see that the flat end rests against the rear side of the crankshaft web. Place the pad in the recess in the front of the crankshaft gear. Enter the bolt through the sleeve, gear pad, and nut. By screwing the bolt into the nut the gear will be withdrawn from the shaft. To hold the nut, a short spanner is provided.

Dismantling of Rear Cover

Remove all external oil pipes. Unscrew the three nuts holding the vertical suction filter into position on the left-hand-side magneto platform and remove filter. Unscrew the bolts fixing the magnetos and flexible couplings. Next remove the gear jet and delivery oil pipe. As the small filter in the banjo on the end of the gear jet pipe is easily damaged if allowed to mix with heavier parts, it should be tied in place in the banjo. The hand-turning gear or starter if fitted should be removed at this stage, together with its adapter. If a starter has not been fitted, remove the four nuts and spring washers, allowing the cover plate to be pulled off

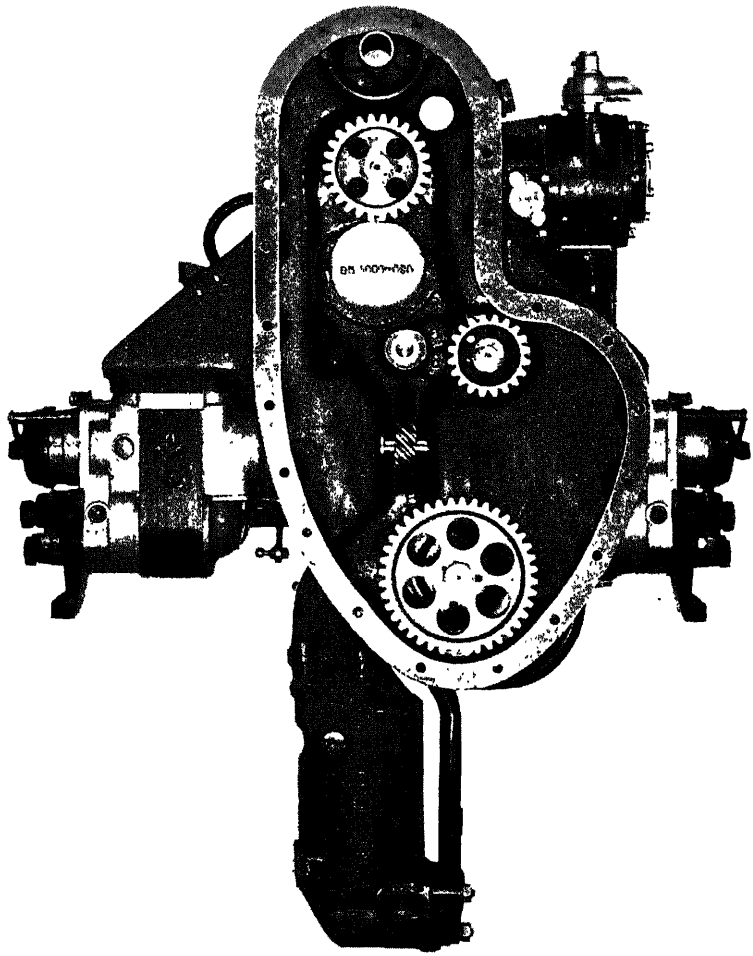

Fig. 8.—INTERIOR OF REAR COVER SHOWING AUXILIARY DRIVES
(*de Havilland Aircraft Co., Ltd.*)

its studs. Remove the vacuum pump and airscrew governor, and remove the nuts from the drive spindles, using box spanners. Next remove the lock-wire, unscrew the large cap nut, and withdraw the "Auto Klean" filter from its casing. Then unscrew the three nuts which attach the filter casing to the rear cover, and remove the filter-casing assembly, complete with cross-shafts, etc.

Dismantling of Oil Pump

Flatten out the tab on the tabwasher which is under the nut holding the oil-pump driving gear to the spindle. Unscrew the nut and ease the driving gear off the spindle. If the gear is supported and the spindle is lightly tapped, the gear should come off the spindle without much difficulty. The nuts and washers which hold the pump assembly to the rear cover should be removed. The pump assembly can be removed from the rear cover by sliding it out of the spigot in the rear cover and then along the studs. To remove the relief valve, straighten out the tab which locks the hexagonal plug in the oil-pump rear cover, unscrew the plug, then the relief-valve piston and spring can be withdrawn. The shims for the relief-valve adjustment will probably remain in position in the piston, but should they come out, check their number to ensure correct reassembly. If necessary, the pump spindle bronze bushes at the driving end can be removed by tapping out of position with a soft drift, whereas the bronze bush pressed into the blind hole of the oil-pump cover must be removed by one of the following methods :

(1) Turn up a plug to be a push fit in the bush and fill the latter with thick grease. Enter the plug in the bush, and press or hammer it in, causing the grease to force the bush out of place. This method will be successful providing the bush is not too tight.

(2) Mount the rear cover on the face plate of a lathe and carefully open up the bore of the bush until only a thin shell remains ; this remaining shell can then be easily pulled, or broken out of position.

Dismantling of Revolution-indicator Drive. Dual Type

Remove the eight 5-mm. nuts and spring washers which hold the revolution-indicator drive gear-box cover to the rear cover. This gear-box cover should then be tapped with a small mallet to break the joint, when it can be withdrawn from the rear cover, complete with its two spur wheels. Bend back the locking tabs and unscrew the nut holding the main revolution-indicator driving spur wheel on to its spindle. Remove the spur wheel, woodruff key, and spindle from the rear cover.

Dismantling of Magneto Drive Shaft

Remove the split pin, nut, and bush from the bolt through the centre of the shaft. Remove the bolt and pull out the flexible coupling drives from either side. Remove the four nuts and spring washers holding the oil swirls in place on either side and pull the swirls off their studs. Tap the steel sleeve which fits the bore of the two ballraces from the right-hand side. This action will force the ballrace on the left-hand side from its housing. Continue to tap the sleeve until it is clear of the spur wheel, allowing this wheel to be lifted from position. It is now a simple matter to remove the remaining ballraces and housings.

Dismantling of Idler Spindle

Flatten out the tab of the tabwasher under the setscrew in the front of the idler spindle. Remove the setscrew and washer. To extract the spindle, use the extractor. Screw the hexagonal part of the extractor on to the threaded part of the idler spindle. Place the sleeve over this part and over the shaft until the end of the sleeve takes a bearing on the boss of the crankcase round the idler-spindle flange. Screw the nut on the thread which projects from the sleeve. By tightening this nut, the idler spindle can be withdrawn from the crankcase.

Dismantling of Cylinder Heads

The rockers and spindles have already been removed as previously described. Place the cylinder head over a small block of wood sufficiently thick to allow the valves to be held in place. Depress the valve collar, using a valve-spring compressor. The collets can then be removed from the valve stems. Remove the compressor and withdraw the springs and collars. After lifting the cylinder head off the wooden block, the valves may be withdrawn. To remove the valve guides use extractor.

Dismantling of Pistons

To remove piston rings from piston, stand it on the bench with skirt downwards, commence with top ring, and slide all rings upwards, that is, towards the crown of the piston.

Inspection of Cylinder Heads

After cleaning and decarbonising all parts, the following points should be noted during the subsequent inspection :

(1) Examine the cylinder heads for cracks.

(2) Carefully examine the valves for any sign of pitting or pocketing and also examine stelliting for cracks. Any signs of picking up or roughness on the valve stems should be smoothed off and polished with a superfine emery cloth. If the valve guides or stems are worn beyond repair tolerances, new parts should be fitted. To avoid damaging the ends of the valve guides on replacement, the soft drift should be used.

(3) The nut holding the valve-rocker bracket should be checked for tightness, and if slack, tighten up and fit a new split pin.

(4) Check the fit of the rocker bush on the spindle. Check the rocker pads for wear. If the wear is only slight, it can be rectified by stoning smooth, but if the contour of the pad is badly affected, a new pad should be riveted into the rocker. Check the cup end in the rocker and the ball on the tappet rod for any signs of pitting or undue wear. If pitted, however slightly, replace by new parts. Check tappet rods for straightness.

(5) Examine steel valve seatings in cylinder head for movement and cracks.

Inspection of Cylinders and Pistons

Cylinders and pistons should now be examined. Check the cylinder for wear, ovality, and scoring of the bore. The piston should be checked for cracks, wear in the gudgeon-pin bores, wear in the ring grooves, and wear on the diameter. Piston rings should be checked for blowing by loss of spring, or excessive gap. Insert the piston in the cylinder and use the crown for squaring the rings when checking the gap. Fit the piston ring to the piston for checking the ring-groove clearance; before doing this, make sure that the ring grooves are free from carbon. Check the gudgeon pin for wear and cracks, check the fit in the connecting rod and piston.

The rings should be squared, and the gap checked at the extreme outer end of the cylinder barrel, that is, where the bore is the smallest diameter.

Inspection of Connecting Rods

Check up small-end bores for wear and ovality, and the small- and big-end bores together for alignment. Examine the connecting-rod bearings for cracks, scoring, and adhesion of the white metal. Assemble on crankshaft and check for clearance and end float. Do not face off the cap to rectify worn bearings ; fit new bearings.

Inspection of Crankshaft and Gears

The crankshaft should be examined for scoring, eccentricity, and ovality of the journals and crankpins. If the scoring is deep or if the eccentricity or ovality is outside tolerance limits, the shaft should be reground. The splines where the airscrew fits should be examined for any signs of damage. If slight burrs are apparent, they should be stoned off carefully. (Should engine have been in a crash, it will be as well to check up to see that the flange is true with internal splines.) Check all gears for chipping, wear, or pitting. If chipping is not very pronounced and is confined to the edges of the teeth, these places can be stoned smooth. Gears worn or pitted very badly should be replaced by new. Check the backlash of the various gears.

Inspection of Main Bearings and Caps

Inspect main-bearing caps for cracks and tightness of dowel pins.

The main bearings should be inspected for cracks and scoring. Assemble the bearings in the crankcase, and check for clearance on the diameter of the crankshaft. Do not face off the caps to rectify worn bearings, fit new ones.

Inspection of Crankcase and Camshaft

Examine the crankcase for general condition and any signs of cracking. Check the tightness of the studs. Check for any signs of flaking of the case or chipped edges on cams and for general condition of the bearings. Any roughness on the edges of the cams should be removed by careful stoning.

Inspection of Crankshaft Thrust Race

Wash the thrust race thoroughly, and examine for any signs of roughness or pitting of the balls on tracks. If defective, however slightly, reject and fit a new bearing. The period of running of the races forms no guide as to their serviceability, as the bearings are adversely affected by condensation if the engine is allowed to stand idle for long periods.

Inspection of Plain Bearings and Tappets

Check plain bearing for tightness of fit and condition. Check the fit of the tappets in the guides and examine the condition of the bearing faces ; examine the heel of the tappets for flaking, cracks, and contour. Test the induction manifold for leaks.

Reassembly of Engine

After all parts have been examined, faulty parts replaced and valves ground in, reassembly should take place in the reverse order to that given for dismantling. The following parts should be replaced by new :

(1) Dermatine rings between cylinder flanges and crankcase.
(2) Dermatine rings between tappet-guide flange and crankcase.
(3) Dermatine rings between tappet-casing tubes.
(4) Copper and asbestos washers between cylinder head and barrel.
(5) Copper and asbestos washers—exhaust ports.
(6) Copper and asbestos washers—oil pipes and filters.
(7) Copper and asbestos washers—main-bearing feed pipes.
(8) Copper and asbestos washers—banjo-airscrew oil-feed pipe.
(9) Copper and asbestos washers—induction ports.
(10) Klingerite washers between carburettor and induction manifold.
(11) Hallite joint—breather connection—timing-gear cover.
(12) Hallite joint—front crankcase drain.
(13) Hallite joint—crankcase breather.
(14) Hallite joint—D.H. A.C. fuel pumps.
(15) Hallite joint—vacuum pump.
(16) Hallite joint—cover—airscrew governor facing.
(17) Hallite joint—oil-tank vent connection.
(18) Hallite joint—cover plate—timing-gear cover drain.
(19) Fibre washer—thrust nut and valve casing.
(20) Fibre washer—small—main oil branch.
(21) Graphited Hallite washer between cylinder head and valve-gear cover.
(22) Diaphragms of fuel pumps.

All oilways and oil pipes should be thoroughly cleared out, using compressed air, if available. Oil all component parts of the engine freely during reassembly.

It should be noted that parts such as connecting rods, main-bearing caps, the more important nuts and bolts, etc., are all marked with

fitting numbers. These numbers should be strictly followed out and the engine reassembled with due consideration to such.

Reassembly of Camshaft and Tappets in Crankcase

The camshaft should be replaced in the crankcase before fitting the tappets and guides and the front and rear bearings bolted in position. This will prevent the tappets falling out while the tappets and guides are being fitted in the crankcase. Dermatine rings should be in place on the tappet guides before these are fitted to the crankcase. Care should be taken to see that the heel of the tappet sits squarely on the face of the cam before the tappet guides are finally tightened in position. When the camshaft is assembled in the crankcase, it should turn quite freely, and the end float should be checked by inserting feeler gauges between the front and rear camshaft bearings and the rear face of the shoulder on the camshaft.

Reassembly of Connecting Rods and Crankshaft

Replace the oil seals in the crankshaft, and retain by means of the central bolt, slotted nuts, and split pins. When refitting the connecting rods to the crankshaft, the big-end nuts should be pulled up dead tight. The nuts should not be slacked back to insert split pins ; should the slot in the nut go beyond the hole in the bolt, the nut should be faced off slightly to bring the next slot in line. The crankshaft gear and starter dog should then be bolted into rear end of crankshaft. Replace the half main bearings to crankcase and lower the crankshaft assembly into place. The shims must be fitted to the connecting-rod bolts before assembly.

Reassembly of Main Bearings, Caps, and Oil Gallery

Fit the half main bearings to the caps, care being taken to see that they are fitted as numbered. The caps should then be fitted and the nuts pulled up dead tight, using the ring spanner. The remarks on big-end nuts also apply in this case. Replace the oil gallery, together with copper-asbestos washers, and retain by means of the cap nuts and locking wire.

The crankshaft at this stage should turn freely by hand.

Reassembly of Camshaft Idler Spindle

Replace the thrust race to idler spindle and press on the front bush. Bolt the magneto driving gear on to flange of camshaft idler gear, together with distance pieces, then press the idler gear into position on spindle ; the rear bush may then be replaced. Replace the washer, nut, and split pin. Refit the assembly to rear of crankcase, and retain with the screw and lockwasher. Care must be taken, when tightening the screw, to see that the small locating pin is not sheared. The end float of the spindle should be adjusted if necessary, by means of shims, which should be placed between the thrust race and the front bush.

Reassembly of Pistons and Cylinder Barrels

It should be noted that the pistons are now made to one weight only and carry the fitting number stamped on the crown. The piston should be fitted on the connecting rod so that this fitting number comes to the same side as the camshaft. The scraper ring should be housed in the inner groove, i.e. the groove farthest from the piston crown. It will be noted that part of the bearing face of this ring is machined away, and the ring must be fitted so that this machining is farthest from the piston crown. When refitting the circlips on the gudgeon pins, use special circlip expander. Circlips when fitted must be tight in the grooves in the gudgeon pins ; if at all slack they must be renewed. A check should be made to see that the gudgeon pins are free to move in the piston and small-end bores. Piston-ring gaps should be spaced equally apart before fitting the pistons in the cylinders. When replacing the cylinders, use the piston-ring clamp to hold the piston rings in place. As the cylinder is pushed over the piston, the clamp will be pushed off, and may be withdrawn before the cylinder is completely in place.

Reassembly of Cylinder Heads

When assembling cylinder head, use the valve-spring compressor and a block of wood inside the head to hold the valves and springs in place while replacing the collets. Replace the rocker brackets complete with rockers. While the cylinder heads are being assembled, make sure that the cylinder baffle brackets and nuts are in place. The cylinder nuts should be screwed up sufficiently tight to hold the heads. The heads should then be lined up with a straightedge against the facing provided for this purpose directly below the port facings. The cylinder heads should then be tightened up at opposite corners alternately. Finally the nuts should be screwed up firmly and evenly all round. It is important that the special spanner only is used for this operation, as using spanners of too great a leverage will result in a distorted cylinder head after the head has warmed up during running of the engine. The hinge pieces to take the airscoop should then be bolted on to the cylinder head and underside of crankcase, and the small oil filter and its housing bolted to the front right-hand side of the crankcase.

Valve Timing

Fit the two tappet rods to No. 1 cylinder and proceed with the valve timing as follows :

(1) Set the crankshaft so that the inlet closed position on the air-screw hub comes opposite the pointer fitted to the crankcase top cover.

(2) Set the tappets on No. 1 cylinder to 0·005 in. clearance.

(3) Set the camshaft so that the clearance is just taken up on the inlet closed position.

(4) Tap the camshaft gear into position, selecting the most suitable

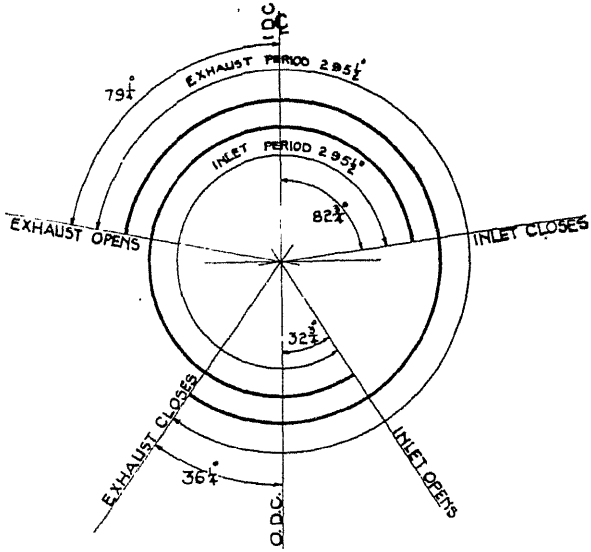

Fig. 9.—Diagram of valve timing

With ·005-in. (·127-mm.) clearance at valves. Angles shown are crankshaft degrees.

keyway from the four provided. Before doing this, the front camshaft bush should first be removed and the camshaft supported with a block of wood ; this will prevent the possibility of damaging the camshaft bush when tapping on the gear. If the crankshaft gear or the camshaft gear has been changed the timing will have to be reset, using the vernier keyways in the camshaft gear. It is possible with this vernier to get the timing within 2° or 3° in all positions.

After temporarily fitting the front-cover assembly, the engine should undergo an oil test under pressure, to ascertain that oil is reaching all parts, and the crankshaft turned to see that the connecting-rod leak holes are clear. After test, remove the front-cover assembly.

Reassembly of Top Cover

When replacing the crankcase top cover, care must be taken to see that the six fitted bolts are entered into their correct holes ; an approved jointing compound should be used on this and other metal-to-metal joints.

Reassembly of Crankshaft, Thrust Race, and Front Cover

During the assembly of the thrust race, the two spring steel washers must be fitted so that they present convex faces to the front and rear respectively of the thrust race.

When fitting the crankcase front cover, centralise this by means of a feeler gauge between the front cover and bronze cone before tightening up the nuts.

Reassembly of Oil Pump

If a new spindle or bushes have been fitted to the oil pump, the specified endfloat will have to be obtained by facing off the bushes.

The oil pump when assembled to the rear cover should turn quite freely by hand. Should any tightness be felt it must be rectified before fitting the rear cover to the engine.

Reassembly of Magneto Drive Shaft

When reassembling the magneto drive shaft in the gear case, the following points should be observed :

The housing for the ballrace and the oil retainer must be fitted on the right-hand side.

Ensure that the oil baffles are in place, and centralised, one on each side of magneto driving gear.

Reassembly of Rear Cover, Tachometer Drive, etc.

Lock the nut holding the oil-pump driving gear to the spindle. When the rear cover is being fitted, make sure that the oil-pump gear is in mesh with the camshaft gear before the rear cover is pushed home.

When reassembling the revolution indicator drive after a new spindle or bushes have been fitted, the necessary endfloat will have to be obtained by facing off the bushes. When replacing the revolution indicator drive gear-box, ensure that the dermatine ring is in place, and that the pin holes are clear in the casing. The constant-speed governor and vacuum-pump assembly may then be bolted into position on the vertical faces provided, the vacuum pump on the left-hand (port) side and constant-speed governor on right-hand side. Replace the pressure oil filter, vertical suction filter, and settling tank. The rear cover should undergo an oil test under pressure to ascertain that oil is reaching all parts, but before doing this the banjo connection on the pressure filter casing should be blanked off.

Setting of Magneto Timing

(1) Set the contact-breaker gap.

(2) Turn crankshaft to "Magneto Advance" mark on airscrew hub, ensuring that No. 1 cylinder is on firing stroke.

(3) Set magneto with points about to break in fully advanced position and distributor opposite No. 1 segment.

(4) Offer up magneto. Turn the rubber coupling round until both sets of teeth enter, one set in magneto coupling and the other set in the coupling in magneto drive gear. When magnetos are finally tightened, there should be a slight end-float on the rubber coupling.

(5) Synchronise magnetos fully advanced with full throttle.

No. 1 cylinder is wired to the front terminal of both magnetos.

When engines are fitted with C.P. airscrews, a timing tool will take the place of the above-mentioned airscrew hub for timing.

Note.—When timing impulse magneto, ensure that impulse starter does not interfere with magneto timing.

Fitting of New Pistons and Connecting Rods

If any new pistons or connecting rods have been fitted, the corresponding cylinders should be assembled in the crankcase before fitting the top cover, so that the side clearance between the connecting rods and the piston bosses can be checked.

Fitting of New Throttle-spindle Bushes

The old bushes must be pressed out of the carburettor body with a suitably stepped drift, and the replacement bushes similarly pressed into position. When they are correctly in place, they must be reamed right through with a $\frac{3}{8}$-in. expanding reamer, suitably adjusted to allow for wear of the throttle spindle. It is important that both bushes are reamed to one setting to ensure alignment of the bores. Should adjustment be necessary to render the throttle valve central in the carburettor body, or endfloat adjusted, this must be effected by skimming the faces of the flanges of the bushes with a facing cutter.

Fitting of New Big-end and Main Bearings

As it is essential that the correct working clearance shall be present at the bearing, a check must be made when checking is complete by the paper-strip method to ensure that the specified clearance has actually been provided. The paper strip should be the length of the bearing and approximately half an inch wide, and of the thickness of the specified minimum clearance new. The strip should be placed in the centre of one half of the bearing. In the case of the connecting rods, the crankpin should be at the inner dead-centre position. Movement of the journal in the bearing with this strip fitted should be comparatively easy ; if it is not, ease the bearing with a scraper as required. If the bearing is slack, insert a paper strip of a thickness equivalent to the maximum clearance new ; with this the journal must be a tight fit in the bearing, otherwise the clearance will be beyond the permissible limit.

Fitting of New Rocker Pads

Remove the old pad by filing off the peening which holds the pad into the rocker, and taking care to be central, drill a 5-mm. hole down the length of the stem of the pad, almost to the pad itself. Knock out the pad with a stepped drift which is a clearance fit in the 5-mm. hole, taking care to employ the minimum weight and number of hammer blows. Offer the new pad into position, making sure that it fits snugly with the small keep on the rocker. Rest the pad on a block of hard brass, and peen over the top of the stem until flush with the surface of the rocker.

Running In of Engine

If possible, the engine should be run in on a special stand and driven by external means. If a stand of this sort is not available, the engine

should be run in at 800–900 r.p.m. for one hour before opening up to full throttle.

RECOMMENDED MAINTENANCE SCHEDULE

The "Gipsy Major" Series II aero engine will normally be inspected and maintained by licensed ground engineers, and their training will indicate the nature of the inspection routine and work to ensure reliable and carefree operation, but for the guidance of all concerned, the following covers broadly the points to be observed.

Daily Inspection in Preparation for Flight

(1) Attention to pilot's previous reports, if any.
(2) Check all controls for free movement and normal operation.
(3) Inspect engines and installation to ensure no slacking, displacement, chafing or leaks.
(4) Rotate spindle in "Auto Klean" filters.
(5) Check fuel pumps independently by operating priming levers.
(6) Run up engines.
(7) Verify engine cowling properly fastened.

After Every 25 Hours' Flying

(1) Routine as daily schedule, including the following:
(2) Remove sparking plugs, dismantle, clean, reassemble, and pressure test.
(3) Check valve clearances and reset if necessary.
(4) Clean suction oil filters.
(5) Clean petrol filters.
(6) Remove and check carburettor jets, and flush through float chamber, including pipe lines between pumps, and carburettor.
(7) Check contact-breaker gap, reset if necessary, and clean distributors.
(8) Drain oil system, including valve-gear covers, replenish with new oil.
(9) Check tightness of airscrew bolts. This should be done more frequently if airscrew of wooden construction is new and if the aeroplane is operating in a hot climate.
(10) Lubricate all working parts of the controls.

After 250 Hours' Flying

The "Auto Klean" pressure filter should be dismantled from its casing and cleaned, including the casing.

After 600 Hours' Flying

The engine should be taken from the airframe and given a complete overhaul.

SCHEDULE OF FITS, CLEARANCES, AND REPAIR TOLERANCES

Notes on Application of Schedule

The data regarding fits and clearances are specified under four headings, i.e. " Dimensions, New," " Permissible Worn Dimensions," " Clearance, New," and " Permissible Worn Clearance."

All dimensions are given in millimetres and decimals of a millimetre except where otherwise stated.

Dimensions, New

The figures in the column " Dimensions, New," are the drawing sizes to which parts are made. These dimensions are given in limit form and represent the minimum and maximum size to which parts may be accepted when new, as for example $\frac{13{\cdot}968}{13{\cdot}981}$ for tappet diameter.

The difference between the minimum and maximum dimensions is known as the manufacturing tolerance. This tolerance is necessary as an aid to manufacturers, and its numerical value is an expression of the accuracy required by the design ; it may also be considered as a numerical expression of the desired quality of workmanship. For the tappet example referred to above the tolerance is 0·013.

Permissible Worn Dimensions

The dimensions in the column " Permissible Worn Dimensions " represent the limits of size to which parts may be worn and refitted for a further period of service.

Note.—These dimensions have been so fixed that the components are fit for the full period of further service which is normally permitted between complete overhauls. When, however, parts are found during complete overhaul to be worn beyond the limits laid down, they must be discarded as unserviceable.

Clearance, New

In the column " Clearance, New," is given the minimum and maximum working clearance obtainable with new parts when assembled together ; and is a function of the minimum and maximum sizes of mating parts in the " Dimensions, New " column. For example, if a new tappet made to the minimum size 13·968 is assembled with a new tappet guide having a bore to the maximum size 14·007, the resulting working clearance will be 0·039 ; similarly, if a new tappet to the maximum size 13·981 is assembled with a new tappet guide to the minimum size 13·993, the resulting working clearance will be 0·012.

Permissible Worn Clearance

The " Permissible Worn Clearance " is the limit of working clearance permissible between any two parts assembled together.

If a male member, worn to the minimum size, is assembled with a corresponding new female part, machined to the minimum drawing limit, the resulting working clearance between the two parts will in most instances correspond with the maximum permissible worn clearance. Similarly, if a female part, worn to the maximum permissible size, is assembled with a corresponding male part, machined to the maximum drawing limit, the resulting working clearance will be the same.

Considering the tappets and guides as an example :

New tappet guide having bore to minimum drawing limit	13·993
Tappet worn to permissible size	13·879
Resulting Clearance	0·114
Tappet guide worn to permissible size	14·095
New tappet to maximum drawing limit	13·981
Resulting clearance	0·114

CRANKCASE, CRANKSHAFT, AND BEARINGS (Fig. 10)

Diag. Ref. No. 10	*Parts and Descriptions*	*Dimensions, New*	*Permissible Worn Dimensions*	*Clearance, New*	*Permissible Worn Clearance*	*Remarks*
(1)	JOURNALS AND BEARINGS STANDARD SIZE :					
	Journal Diameter . . .	51·968	51·417	0·063	0·127	Minimum worn size. Unless new bearings are required, bearings which are found to be within the limit of wear before being refitted are to be carefully inspected to ensure that the white metal is in a serviceable condition. Permissible worn journal size shown gives a wear tolerance of 0·051 after fourth stage of regrind.
		51·987				
	Bearings Bore . . .	52·050	52·114	0·088		
		52·056 (Finished Size)				
	Journals, Stages of regrinding :					
	1st	51·843	—	—	—	When regrinding, care is to be taken to see that no material is removed from the face of the crankwebs.
		51·862				
	2nd	51·718	—	—	—	
		51·737				
	3rd	51·593	—	—	—	
		51·612				
	4th	51·468	—	—	—	
		51·487				
	Journal Ovality . . .		0·05			
	JOURNALS BEARINGS, STAGES OF UNDERSIZE : . . .					
	1st	51·925	—	—	—	
		51·931				

	2nd	51·800	—	—	—	
		51·806				
	3rd	51·675	—	—	—	
		51·681				
	4th	51·550	—	—	—	
		51·556				
(2)	CRANKPINS, STANDARD SIZE:					
	Crankpin Diameter	49·968	49·898 (see remarks)	0·038	0·127	Minimum worn size.
		49·987		0·063		
	Crankpins, Stages of regrinding:					
	1st	49·843	—	—	—	When regrinding, care is to be taken to see that no material is removed from the face of the crankwebs.
		49·862				
	2nd	49·718	—	—	—	
		49·737				
	3rd	49·593	—	—	—	
		49·612				
	4th	49·468	—	—	—	
		49 487				
	Crankpins, Ovality		0·05	—	—	
(3)	CRANKPINS, LENGTH	50·988	51·142	—	—	
		51·012				
(4)	CRANKPINS, PARALLELISM:					
	Lack of parallelism of crankpin with journals per inch of length	—	0 040	—	—	Measured in two planes at 90°.
(5)	CRANKSHAFT END FLOAT:					
	Crankshaft ball bearings end float between inner and outer races	—	—	0·002″ / 0 003″	—	

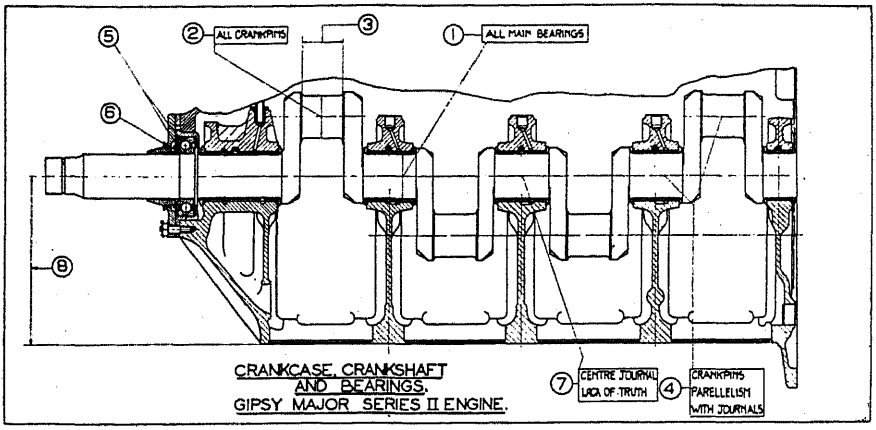

Fig. 10.—CRANKCASE, CRANKSHAFT, AND BEARINGS

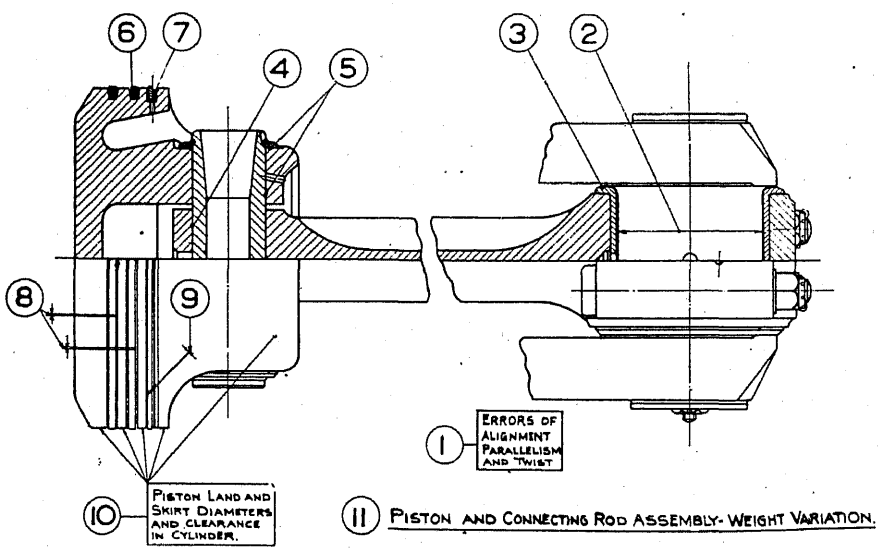

Fig. 11.—PISTONS AND CONNECTING RODS

CRANKCASE, CRANKSHAFT, AND BEARINGS (Fig. 10)—*continued*

Diag. Ref. No. 10	*Parts and Descriptions*	*Dimensions, New*	*Permissible Worn Dimensions*	*Clearance, New*	*Permissible Worn Clearance*	*Remarks*
(6)	CRANKSHAFT FRONT COVER :					
	Rear cone (diameter on swirl) .	71·424 / 71·462	71·364	0·198 / 0·276	0·296	
	Front cover bore	71·660 / 71·700	71·758			
(7)	CRANKSHAFT CENTRE JOURNAL, LACK OF TRUTH : Lack of truth of centre journal when crankshaft is supported by journals one and five in "V" blocks (errors due to ovality to be subtracted) .	—	0·05	—	—	Dial indicator readings 0·100 — 0·004".
(8)	WEAR ON FACE OF CRANKCASE CAUSED BY FRETTING OF CYLINDER BARRELS . .	—	0·250 (see remarks)	—	—	When this figure is exceeded, the crankcase face is to be machined down, and a packing shim representing the thickness of metal removed is to be fitted under the cylinder-barrel flanges. Four stages of refacing are allowed. The maximum amount of metal which may be removed is 1·250, which represents a dimension of $\frac{192{\cdot}700}{192{\cdot}850}$ between the top and bottom faces of the crankcase. When this stage is reached, the face may be allowed to wear down 0·25, after which the crankcase is to be discarded.

PISTONS AND CONNECTING RODS (Fig. 11)

Diag. Ref. No. 11	*Parts and Descriptions*	*Dimensions, New*	*Permissible Worn Dimensions*	*Clearance, New*	*Permissible Worn Clearance*	*Remarks*
(1)	CONNECTING RODS, ERRORS OF ALIGNMENT: Errors of alignment, big and small ends. Per inch of mandrel:					
	Parallelism	—	0·51	—	—	
	Twist	—	0·076	—	—	
(2)	BIG-END BEARINGS:					
	Bore, standard size	50·025 / 50·031	50·114	—	—	
	STAGES OF UNDERSIZE:					
	Bore 1st	49·900 / 49·906	—	—	—	
	2nd	49·775 / 49·781	—	—	—	
	3rd	49·650 / 49·656	—	—	—	
	4th	49·525 / 49·531	—	—	—	
(2)	BIG-END BEARINGS: Working clearance for big-end bearings on crankpins	—	—	0·038 / 0·063	0·127	Unless new bearings are required, bearings which are found to be within the limits of wear are to be carefully inspected to ensure that the white metal is in a serviceable condition before being refitted.

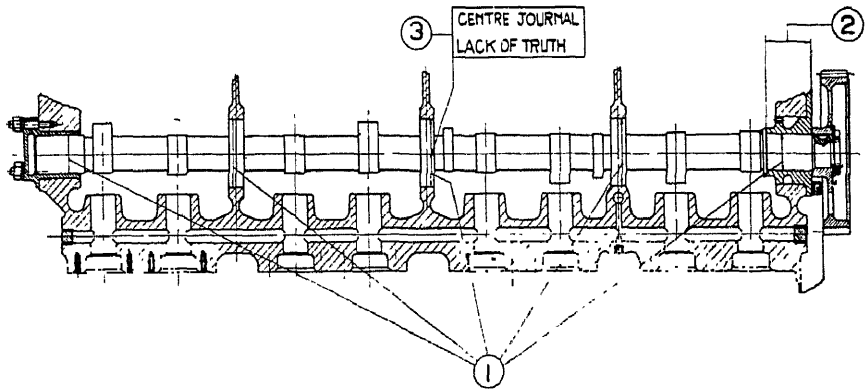

Fig. 12.—CAMSHAFT AND BEARINGS

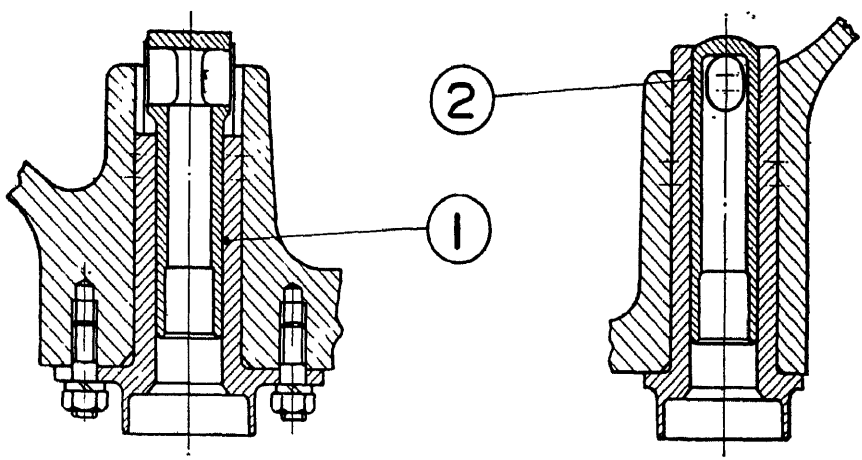

Fig. 13.—TAPPETS AND GUIDES

PISTONS AND CONNECTING RODS (Fig. 11)—*continued*

Diag. Ref. No. 11	*Parts and Descriptions*	*Dimensions, New*	*Permissible Worn Dimensions*	*Clearance, New*	*Permissible Worn Clearance*	*Remarks*
(3)	BIG-END BEARINGS END FLOAT:					
	Big-end bearings, width	50·862 / 50·888	50·734	—	—	
	End float of big-end bearings on crankpins	—	—	0·100 / 0·150	0·254	To obtain increased nip on connecting-rod bearings, 0·0045″ $+^{\cdot 0003\frac{1}{2}''}_{-\cdot 000''}$ may be taken off both sides of cap, and connecting rod tightened to take up this clearance.
(4)	GUDGEON PINS IN CONNECTING RODS:					
	Small end, bore	25·000 / 25·020	25·070	0·006	0·076	
	Gudgeon pin, diameter in centre	24·981 / 24·994	24·924	0·039		
	Gudgeon pin, Ovality	—	0·025	—	—	Minimum diameter to be such that "permissible worn clearance" for gudgeon pin is not exceeded.
(5)	GUDGEON PIN IN PISTON:					
	Gudgeon-pin boss, bore	24·993 / 25·013	25·062	0·001 tight	0·068	
	Gudgeon pin, diameter at ends	24·981 / 24·994	24·925	0·032 slack / 0·0355″		
	End float	—	—	0·059″	0·068″	

(6)	COMPRESSION RINGS IN RING GROOVES:					
	Compression ring groove width, Inner	2·134 / 2·146	2·274	0·115 / 0·152	0·255	
	Compression ring width, Inner	1·994 / 2·019	1·879			
	Compression ring groove width, Outer	2·134 / 2·146	2·274	0·115 / 0·152	0·255	
	Compression ring width, outer	1·994 / 2·019	1·879			
(7)	SCRAPER RINGS IN RING GROOVES:					
	Scraper ring groove width	2·625 / 2·650	2·730	0·125 / 0·162	0·230	
	Scraper ring width	2·488 / 2·500	2·395			
(8)	COMPRESSION-RING GAP: Measured when piston is at small end of cylinder, i.e. nearest combustion chamber	—	—	0·012″ / 0·020″	0·035″	
(9)	SCRAPER-RING GAP: Measured when piston is at small end of cylinder, i.e. nearest combustion chamber	—	—	0·005″ / 0·011″	0·044″	
(10)	PISTONS, LAND AND SKIRT DIAMETERS AND CLEARANCE IN CYLINDER:					
	Diameter of skirt: Top (Adjacent to scraper ring)	117·140 / 117·190	117·070 (see remarks)	0·565 / 0·665	0·905	Measured in large end of cylinder, i.e. farthest from combustion chamber.

PISTONS AND CONNECTING RODS (Fig. 11)—*continued*

Diag. Ref. No.	*Parts and Descriptions*	*Dimensions, New*	*Permissible Worn Dimensions*	*Clearance, New*	*Permissible Worn Clearance*	*Remarks*
11						
	Bottom	117·335 117·385	117·125 (see remarks)	0·370 0·470	0·850	
	Diameter of crown of piston	116·927 116·953	—	—	—	
	Clearance between piston and cylinder when measured at small end of cylinder, i.e. nearest combustion chamber:					
	Top Land	—	—	0·597 0·673	0·597 0·973	
	2nd Land	—	—	0·597 0·673	0·597 0·973	
	3rd Land (near piston crown)	—	—	0·802 0·878	0·802 1·528	
(11)	PISTONS AND CONNECTING-RODS ASSEMBLY, WEIGHT VARIATION: Permissible variation in weight between any two connecting rods, complete with gudgeon pins and pistons and all details, in any individual engine	— 1 oz.—10 drms.		—	—	

CAMSHAFT AND BEARINGS (Fig. 12)

Diag. Ref. No. 12	*Parts and Descriptions*	*Dimensions, New*	*Permissible Worn Dimensions*	*Clearance, New*	*Permissible Worn Clearance*	*Remarks*
(1)	CAMSHAFT AND BEARINGS :					
	Bearings, front and rear, bore	27·993 / 28·019	28·158	0·025 / 0·083	0·190	Crankcase repair operation to fit camshaft bushes.
	Journals, front and rear, diameter	27·936 / 27·968	27·803			
	Bearings, intermediate, bore	50·972 / 50·985	51·112	0·025 / 0·063	0·165	
	Journals, intermediate, diameter	50·922 / 50·947	50·807			
(2)	CAMSHAFT END FLOAT :					
	Camshaft, width between flange on camshaft and face of timing gear	38·050 / 38·100	38·203	0·025 / 0·125	0·178	
	Rear-end bush, width	37·975 / 38·025	37·872			
(3)	CAMSHAFT CENTRE JOURNAL, LACK OF TRUTH :					
	Lack of truth of centre journal when front and rear journals are supported on " V " blocks	—	0·050	—	—	Dial indicator reading 0·100 = 0·004".

TAPPETS AND GUIDES (Fig. 13)

Diag. Ref. No. 13	*Parts and Descriptions*	*Dimensions, New*	*Permissible Worn Dimensions*	*Clearance, New*	*Permissible Worn Clearance*	*Remarks*
(1)	TAPPETS, CYLINDRICAL PORTION IN GUIDES:					
	Guide bore	13·993 / 14·007	14·095	0·012 / 0·039	0·114	
	Tappet diameter	13·968 / 13·981	13·879			
(2)	TAPPETS, RECTANGULAR PORTION IN GUIDES:					
	Guide slot, width	13·993 / 14·020	14·133	0·012 / 0·052	0·152	
	Tappet flat, width	13·968 / 13·981	13·841			

CYLINDERS, VALVES, AND ROCKER GEAR (Fig. 14)

Diag. Ref. No. 14	*Parts and Descriptions*	*Dimensions, New*	*Permissible Worn Dimensions*	*Clearance, New*	*Permissible Worn Clearance*	*Remarks*
(1)	CYLINDER BORE :					
	Measured at small end of cylinder	117·755 / 117·805	117·955	—	—	Local wear at top of cylinder bore may be permitted up to 0·200 above the max., new dimension, i.e. 117·805 + 0·200 = 118·005.
	Measured at large end of cylinder	117·975 / 118·025	118·175	—	—	
	Ovality, measured at small end of cylinder, i.e. nearest to the cylinder head	—	0·076	—	—	
	Ovality, measured at large end of cylinder, i.e. farthest from cylinder head	—	0·076	—	—	
	Stage of regrind :					
	Measured at small end of cylinder	117·955 / 118·005	—	—	—	
	Measured at large end of cylinder	118·175 / 118·225	—	—	—	
(2)	VALVES IN GUIDES. VALVE GUIDE INLET :					
	Bore measured 12 mm. from either end	11·050 / 11·070	11·170	0·080 / 0·120	0·200	
	Valve inlet, stem diameter	10·950 / 10·970	10·850			

CYLINDERS, VALVES, AND ROCKER GEAR (Fig. 14)—*continued*

Diag. Ref. No. 14	*Parts and Descriptions*	*Dimensions, New*	*Permissible Worn Dimensions*	*Clearance, New*	*Permissible Worn Clearance*	*Remarks*
	VALVE GUIDE, EXHAUST:					
	Bore measured 12 mm. from either end	11·050 / 11·070	11·170	0·080 / 0·120	0·200	
	Valve, Exhaust, stem diameter	10·950 / 10·970	10·850			
(3)	VALVES, INLET AND EXHAUST: Ovality of stems	—	0·076	—	—	Minimum diameter to be within "permissible worn dimensions" for valve stems.
(4)	VALVE GUIDE BORES, OVALITY, VALVE GUIDES, INLET AND EXHAUST, OVALITY OF BORE: Bore measured 12 mm. from either end	—	0·076	—	—	Minimum diameter to be within "permissible worn dimensions" for valve guides.
(5)	VALVE SPRINGS, INLET AND EXHAUST:					
	OUTER SPRINGS: Test length	1·579″	—	—	—	
	Equivalent load	56·1 lb. / 58·6 lb.	53·75 lb.	—	—	
	INNER SPRINGS: Test length	1·579″	—	—	—	
	Equivalent load	38·1 lb. / 40·1 lb.	36·85 lb.	—	—	

(6)	VALVE SEATS IN CYLINDER HEAD, DIAMETER OF 30° SEATINGS:					
	Inlet	50·450 / 50·550	52·0	—	—	
	Exhaust	47·950 / 48·050	49·5	—	—	
(7)	VALVES, REGRINDING:					
	Valves, minimum thickness of valve after regrinding of valve face (i.e. dimension from lower edge of valve face to bottom of valve head):					
	Inlet valve	1·5	0·750	—	—	
	Exhaust valve	3·26	2·780	—	—	
(8)	VALVE ROCKER:					
	BUSHES ON SPINDLE:					
	Bushes, bore	13·993 / 14·007	14·095	0·012 / 0·039	0·114	
	Spindle, diameter	13·968 / 13·981	13·879			
(9)	VALVE ROCKER:					
	End float	—	—	0·008″ / 0·016″	—	
(10)	VALVE-ROCKER PAD:					
	Thickness of head	3·5	3·1	—	—	Valve-rocker pad may be reconditioned within the limits stated by hand-stoning contact face. Care must be taken to keep the face true with longitudinal axis of pad.
(11)	VALVE GUIDES IN CYLINDER HEAD	—	—	—	—	Should guides become loose in cylinder head, the head may be bored out.

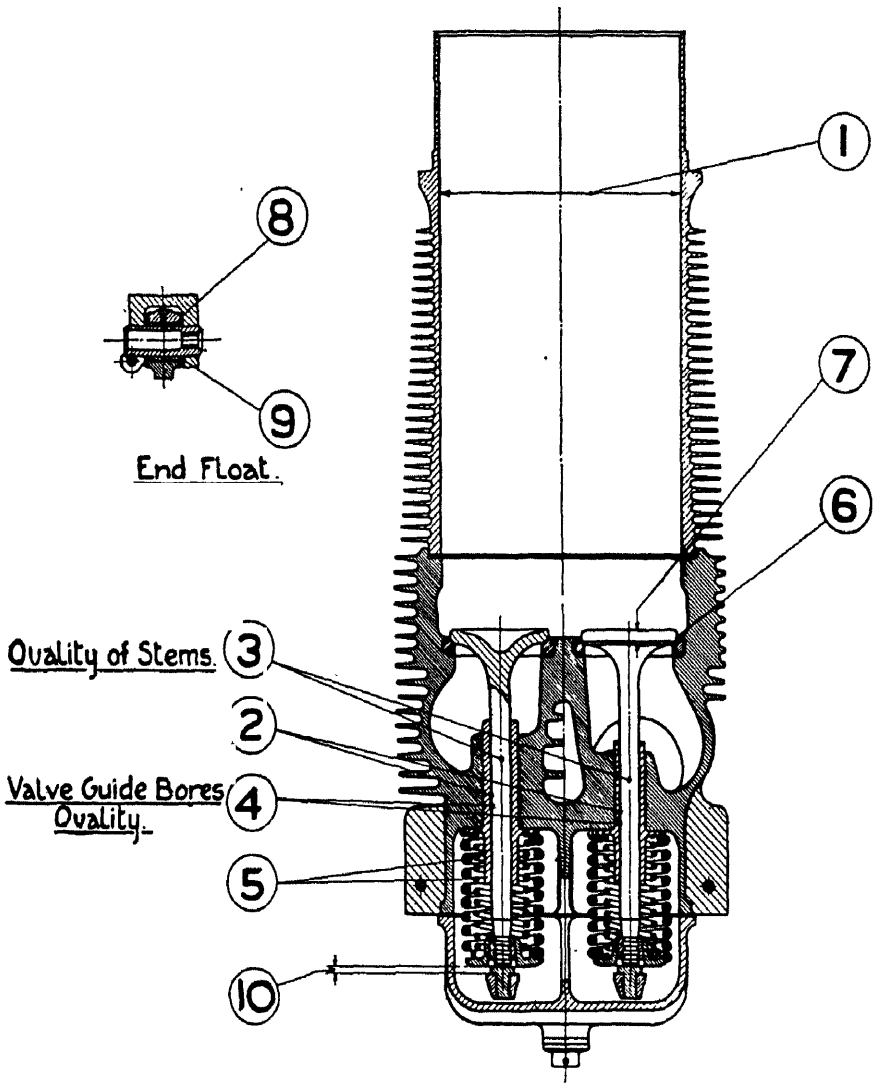

Fig. 14.—CYLINDERS, VALVES, AND ROCKER GUIDES

MAGNETO-DRIVEN GEAR (Fig. 15)

Diag. Ref. No. 15	*Parts and Descriptions*	*Dimensions, New*	*Permissible Worn Dimensions*	*Clearance, New*	*Permissible Worn Clearance*	*Remarks*
(1)	MAGNETO-DRIVEN GEAR ASSEMBLED ON CROSS SHAFT: End float	—	—	0·003″ / 0·008″	0·011″	
(2)	Backlash	—	—	0·005″ / 0·010″	0·015″	

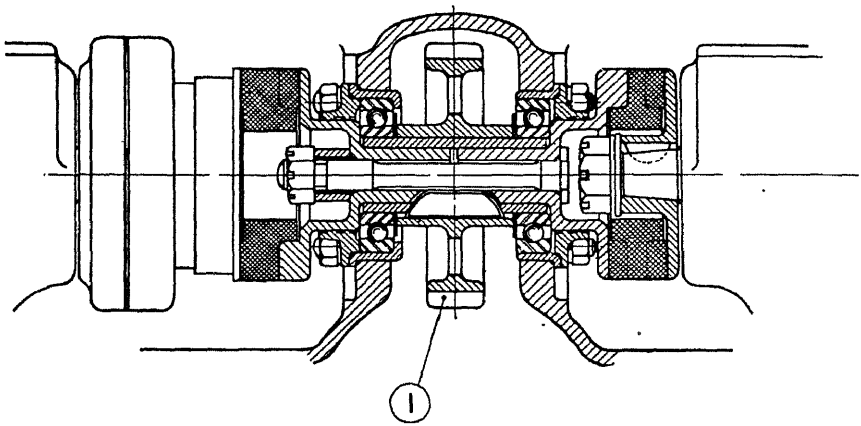

Fig. 15.—MAGNETO-DRIVEN GEAR

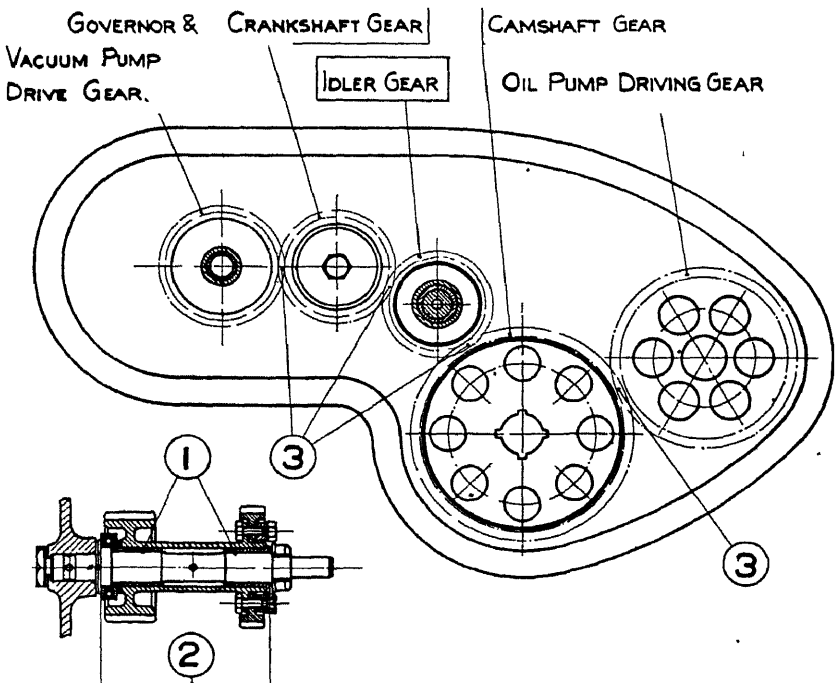

Fig. 16.—TIMING GEARS

TIMING GEARS (Fig. 16)

Diag. Ref. No. 16	*Parts and Descriptions*	*Dimensions, New*	*Permissible Worn Dimensions*	*Clearance, New*	*Permissible Worn Clearance*	*Remarks*
(1)	IDLER GEAR, ASSEMBLED WITH BUSHES ON SPINDLE:					
	Bushes bore	17·993 / 18·013	18·068	0·065 / 0·098	0·140	
	Spindle diameter	17·915 / 17·928	17·853			
(2)	End float	—	—	0·002″ / 0·004″	0·015″	Adjustable by shim between thrust race and shoulder of bearing bush. Shims are supplied in the following range of thicknesses 0·002″, 0·005″, 0·010″.
(3)	TIMING GEARS (SPUR): Backlash between any pair	—	—	0·0035″ / 0·007″	—	

TACHOMETER DRIVES (Fig. 17)

Diag. Ref. No. 17	*Parts and Descriptions*	*Dimensions, New*	*Permissible Worn Dimensions*	*Clearance, New*	*Permissible Worn Clearance*	*Remarks*
(1)	DRIVEN GEAR TACHOMETER SHAFT:					
	Bushes bore	11·993 / 12·007	12·070	0·025 / 0·062	0·102	
	Spindle diameter	11·945 / 11·968	11·891			
	Width over bushes	74·850 / 74·890	74·721	0·110 / 0·187	0·279	
	Spindle length	75·000 / 75·037	75·169			
(2)	End float	—	—	0·0043 / 0·0073″	0·011″	

(3)	Gear backlash . . .	—	—	0·0035″ / 0·0075″	0·010″
(4)	DRIVEN AND DRIVING GEAR IN BEARINGS:				
	Bearing bore	11·993 / 12·007	12·070	0·025 / 0·062	0·102
	Spindle diameter . . .	11·945 / 11·968	11·891		
	Housing width . . .	8·050 / 8·125	8·275	0·075 / 0·200	0·300
	Gears width	7·925 / 7·975	7·750		
(5)	End float	—	—	0·003″ / 0·008″	0·012″
(6)	Backlash	—	—	0·004″ / 0·006″	0·010″

OIL PUMP (Fig. 18)

Diag. Ref. No. 18	Parts and Descriptions	Dimensions, New	Permissible Worn Dimensions	Clearance, New	Permissible Worn Clearance	Remarks
(1)	PUMP BEARINGS :					
	Bushes bore	15·993 / 16·013	16·089	0·018 / 0·064	0·114	
	Journal diameter	15·949 / 15·975	15·879			
(2)	PUMP GEARS :					
	Backlash	—	—	0·008″ / 0·012″	0·016″	
(3)	OIL PUMP DRIVING GEAR :					
	End float	—	—	0·038 / 0·109	0·178	
	Backlash	—	—	0·002″ / 0·006″	0·008″	
(4)	PUMP GEARS IN CASING :					
	Pump casing with bushes fitted, width between flanges	25·050 / 25·124	25·153	0·075 / 0·174	0·178	
	Pump gear length	24·950 / 24·975	24·872			
(5)	PUMP GEARS CLEARANCE ON DIAMETER :					
	Pump casing bore	35·493 / 35·545	35·593	0·008 / 0·175	0·200	
	Pump gears, diameter over teeth	35·370 / 35·395	35·293			

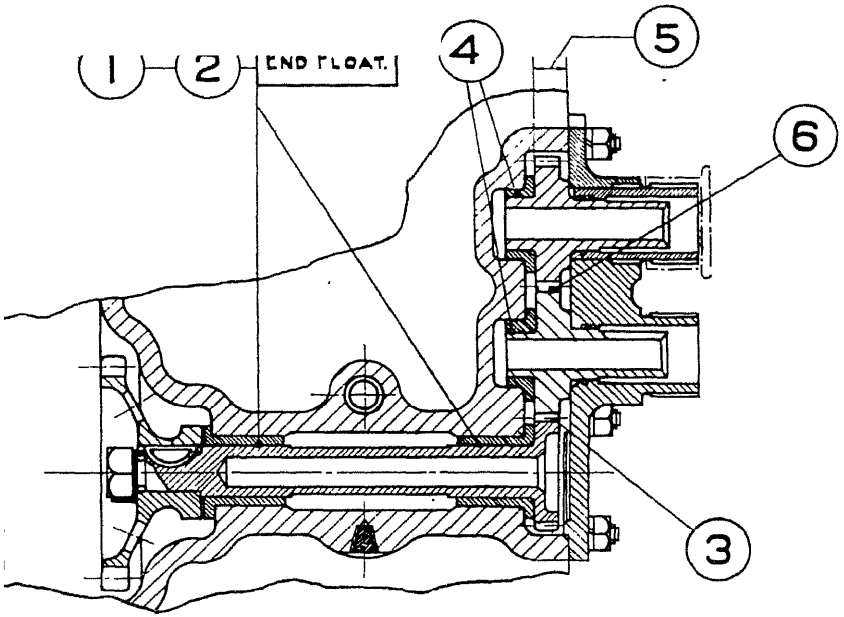

Fig. 17.—TACHOMETER DRIVES

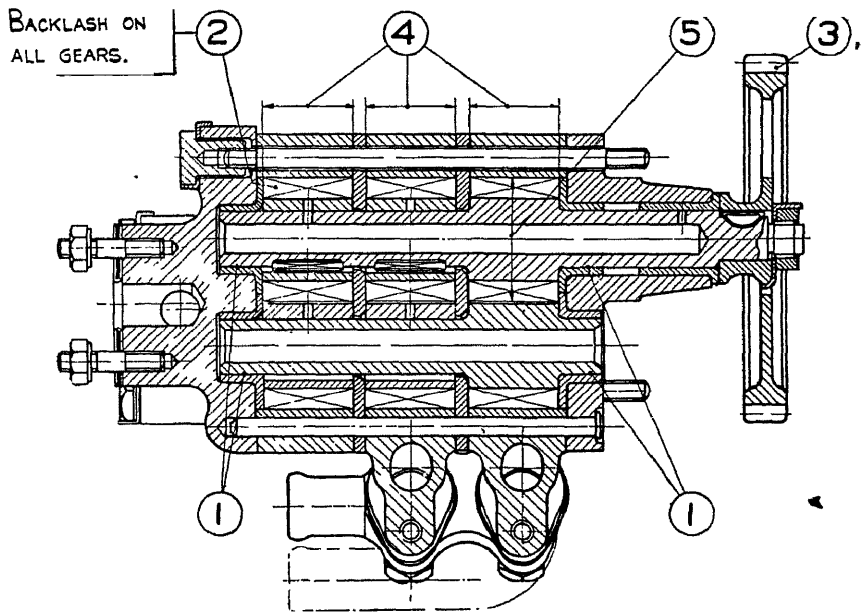

Fig. 18.—OIL PUMP

VACUUM PUMP AND AIRSCREW GOVERNOR DRIVE (Fig. 19)

Diag. Ref. No. 19	*Parts and Descriptions*	*Dimensions, New*	*Permissible Worn Dimensions*	*Clearance, New*	*Permissible Worn Clearance*	*Remarks*
(1)	MAIN-DRIVE SHAFT HOUSING :					
	Bushes bore	17·993 / 18·013	18·089	0·018 / 0·064	0·114	
	Drive shaft diameter	17·949 / 17·975	17·879			
	Width over bushes	36·950 / 36·975	36·850	0·075 / 0·125	0·200	
	Spindle length	37·050 / 37·075	37·175			
	End float	—	—	0·003″ / 0·005″	0·008″	
(2)	Backlash spur gear	—	—	0·003″ / 0·007″	0·010″	
(3)	Backlash bevel pinion	—	—	0·003″ / 0·008″	0·012″	
(4)	AIRSCREW GOVERNOR DRIVE :					
	Housing bore	27·993 / 28·019	28·158	0·025 / 0·083	0·190	
	Bevel pinion spindle diameter	27·936 / 27·968	27·803			

VACUUM PUMP AND AIRSCREW GOVERNOR DRIVE (Fig. 19)—*continued*

Diag. Ref. No.	*Parts and Descriptions*	*Dimensions, New*	*Permissible Worn Dimensions*	*Clearance, New*	*Permissible Worn Clearance*	*Remarks*
19						
	Housing width . . .	31·950 / 31·975	31·850	0·075 / 0·125	0·200	
	Spindle length . . .	32·050 / 32·075	32·175			
	End float	—	—	0·003″ / 0·005″	0·008″	
(5)	Backlash, bevel pinion . .	—	—	0·003″ / 0·008″	0·012″	
(6)	VACUUM PUMP DRIVE:					
	Housing bore	22·993 / 23·013	23·089	0·018 / 0·064	0·114	
	Bevel pinion spindle diameter .	22·949 / 22·975	22·879			
	Housing width . . .	21·950 / 21·975	21·850	0·075 / 0·125	0·200	
	Spindle length . . .	21·050 / 22·075	22·175			
	End float	—	—	0·003″ / 0·005″	0·008″	
(7)	Backlash, bevel pinion . .	—	—	0·003″ / 0·008″	0·012″	

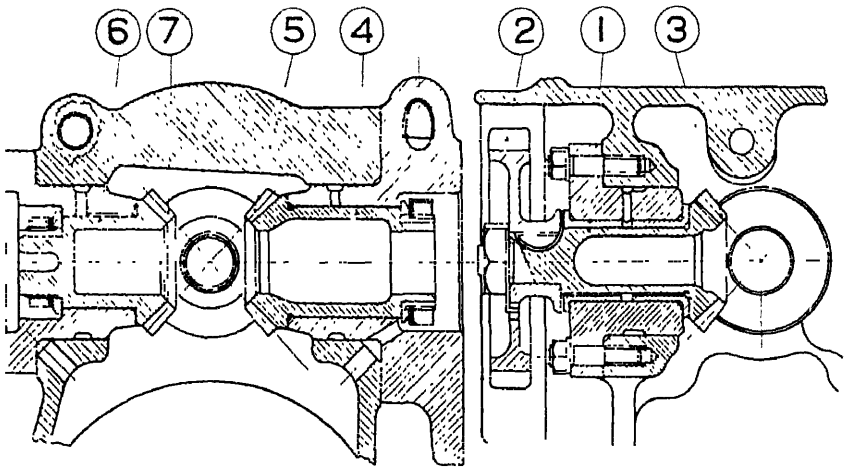

Fig. 19.—VACUUM PUMP AND AIRSCREW GOVERNOR DRIVE

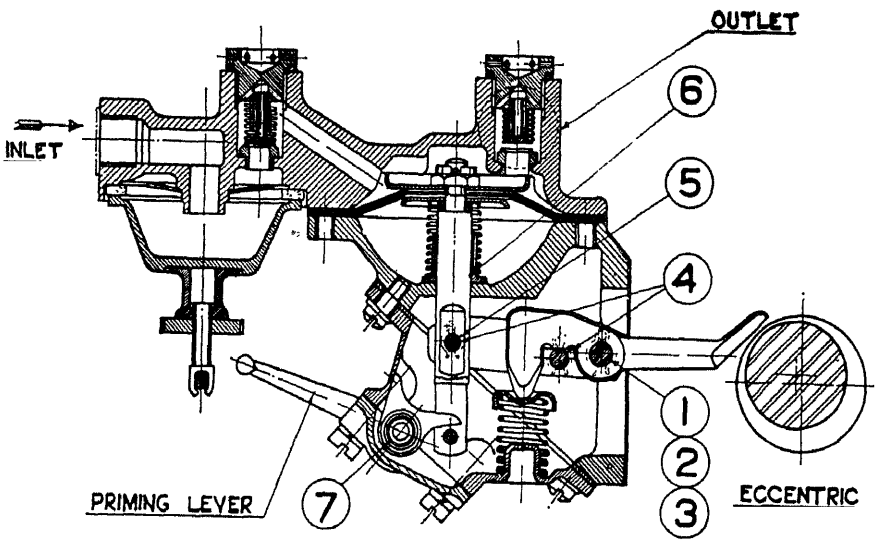

Fig. 20.—D.H. A.C. FUEL PUMP

D.H. A.C. FUEL PUMP (Fig. 20)

Diag. Ref. No. 20	Parts and Descriptions	Dimensions, New	Permissible Worn Dimensions	Clearance, New	Permissible Worn Clearance	Remarks
(1)	ROCKER ARM PIN IN LEVER:					
	Pin diameter	0·2445″ / 0·245″	0·2405″			
	Lever bore	0·2455″ / 0·2475″		0·0005″ / 0·0030″	0·005″ (see remarks)	Permissible worn clearance of 0·005″ applies only to that portion of the pin on which rocker lever and links have their bearings.
(2)	ROCKER ARM PIN IN LINK:		0·250″			
	Link bore	0·2455″ / 0·2475″				
(3)	ROCKER ARM PIN IN BODY:					
	Body bore	0·2435″ / 0·2445″	—	(See remarks)	—	Rocker arm pin in body on diameter 0·0015″ tight. / Size
(4)	LINK PINS IN LINKS:					
	Link bore	0·184″ / 0·186″	0·1885″	0·0020″ / 0·0045″	0·0065″	
	Link pin diameter	0·1815″ / 0·1820″	0·1775″			

D.H. A.C. FUEL PUMP (Fig. 20)—*continued*

Diag. Ref. No. 20	*Parts and Descriptions*	*Dimensions, New*	*Permissible Worn Dimensions*	*Clearance, New*	*Permissible Worn Clearance*	*Remarks*
(5)	LINK PIN IN PULL ROD :					
	Pull rod bore	0·1825″ / 0·1845″	0·1870″	0·0005″ / 0·0030″	0·005″	
	Link pin diameter . . .	0·1815″ / 0·1820″	0·1775″			
(6)	PULL ROD IN GLAND :					
	Gland bore	0·380″ / 0·382″	0·386″	0·005″ / 0·009″	0·011″	
	Pull rod diameter . . .	0·373″ / 0·375″	0·369″			
(7)	PRIMING LEVER IN BOTTOM COVER AND CAP :					
	Bottom cover and cap bore .	7·993 / 8·007	8·132	0·493 / 0·507	0·632	
	Priming lever diameter . .	7·5 / 7·5	7·361			

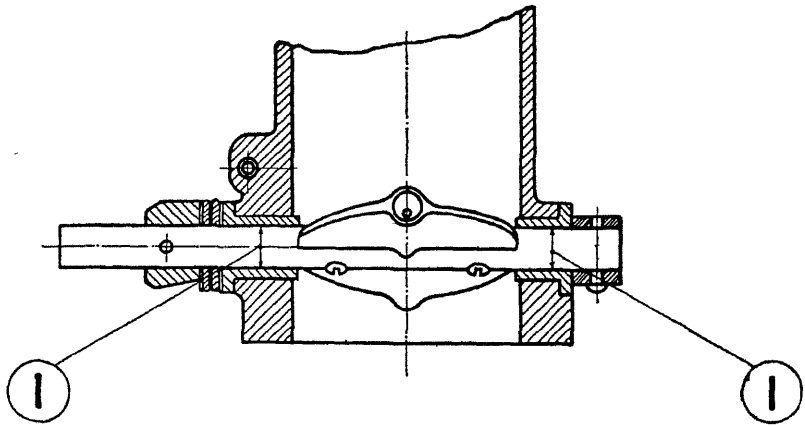

Fig. 21.—CARBURETTOR

CARBURETTOR (Fig. 21)

Diag. Ref. No. 21	*Parts and Descriptions*	*Dimensions, New*	*Permissible Worn Dimensions*	*Clearance, New*	*Permissible Worn Clearance*	*Remarks*
(1)	THROTTLE SPINDLE : Bush bore . .	0·3755″ / 0·3765″	0·379″	0·0005″ / 0·002″	0·004″	Bushes—hand reamed, if necessary, when assembled in carburettor body to give minimum clearance of 0·0005″.
	Spindle . .	0·3745″ / 0·375″	0·3715″			

Acknowledgment

The above notes on the maintenance of the Gipsy Major Series II Engine have been extracted from the instruction book issued by the De Havilland Aircraft Co., Ltd. We take this opportunity of expressing our indebtedness to the De Havilland Aircraft Co., Ltd., for their courteous co-operation in enabling us to publish these details.

GIPSY "II" AND "III" ENGINES

MANY of the main components of the "Gipsy II" and "III" engines are identical, and it is for this reason that these two engines are dealt with together in the following pages.

Both are four-cylinder, air-cooled, in-line engines, the "Gipsy II" being "vertical" and the Gipsy III" "inverted."

GENERAL DESCRIPTION

Cylinder Heads

The cylinder head is separate from the cylinder and is held to this part by four high-tensile steel bolts screwed into the crankcase. The joint between the head and the cylinder is made by a copper and asbestos washer which fits in a recess in the cylinder head. Provision is made for one inlet and one exhaust valve in each cylinder head. Two sparking plugs are fitted, one on each side of the cylinder head. The inlet and exhaust ports are on one side of the engine. The cylinder heads on the early engines were an aluminium-alloy casting with shrunk-in aluminium-bronze valve seatings, but later engines have the cylinder heads cast in aluminium-bronze, and the valve seatings are formed directly in the material of the head.

Cylinders

The cylinders are steel forgings machined all over.

Pistons

The pistons are of the slipper type cast in aluminium. Three rings are fitted, the rings nearest the gudgeon pin being of the scraper type.

Connecting Rods

On early engines the connecting rods were forgings in "Y" alloy, but later this was changed to specification D.T.D. 130. Leak holes are provided in the cap of the rod and bearing to ensure cylinder and piston lubrication.

Crankshaft

The crankshaft is a one-piece forging of special steel.

Crankcase

This is a deep-section casting in aluminium-alloy, the front wall and a tapered section between them carrying the housing for the long front

LEADING PARTICULARS

Type :

"Gipsy II" : 4-cylinder, vertical, air-cooled, in-line, direct drive, wet sump.

"Gipsy III" : 4-cylinder, inverted, air-cooled, in-line, direct drive, dry sump.

Rotation : Left-hand tractors.

Bore : 114 mm.

Stroke : 140 mm.

Capacity : 5,713 c.c.

Maximum b.h.p. at normal r.p.m. : 108–110 at 2,000 r.p.m.

Maximum b.h.p. at maximum r.p.m. : 120 h.p. at 2,300 r.p.m.

Compression ratio : 5·2 to 1.

Weight complete with airscrew boss :

"Gipsy II" : 298 lb. (approx.).

"Gipsy III" : 290 lb. (approx.).

Fuel consumption : 0·57 pint per b.h.p. per hour.

Fuel consumption per hour 9/10 throttle at 2,000 r.p.m. : 6·75 gallons (approx.).

Fuel consumption per hour at full throttle at 2,300 r.p.m. : 9 gallons (approx.).

Oil consumption : 1¼ pints per hour (approx.).

Oil pressure : 40 to 45 lb. per square inch (35 lb. per square inch minimum).

Oil temperature : Inlet 50°–70° C. (maximum 85° C.).

Oil in circulation : 8 pints (minimum permissible).

Carburettor :

"Gipsy II" : Hobson A.V. 48D.

"Gipsy III" : (early engines) : Hobson A.H. 45D.

"Gipsy III" (later engines) : Hobson A.I. 48.

Magnetos :

One B.T.H. A.G. 4–4 anti-clockwise.

One B.T.H. A.G. 4–4 clockwise, fitted with impulse-starter unit.

Sparking plugs : K.L.G. 294, 633, V.12, and Lodge A.55.

Fuel pump when required : Early engines A.C. Sphinx, but later D.H.A.C.

Fuel : Any good-grade automobile fuel with minimum octane value 70, obtained by the C.F.R. motor method (modified to 260° F. mixture temperature) without the use of tetra-ethyl-lead.

Oil : Oil to specification D.T.D. 109, and a range of proprietary brands are also approved by the manufacturers.

Fig. 1.—RECOMMENDED DAILY MAINTENANCE ROUTINE (1)

When making an external inspection look for chafing, looseness, or displacement of parts.

main bearing. The rear-bearing housing is carried by the rear wall of the crankcase.

Each of the intermediate bearings is in a housing, supported by stiff cross-webs. All main bearings are held in separate caps, thus facilitating assembly, overhaul, and inspection, as none of the bearings need be disturbed when the sump is removed. Facings for engine-bearer feed, oil filler, and breathers are provided for on this member.

Camshaft

The camshaft is of special steel and rotates in five plain bearings, which, with the tappets, are lubricated by oil mist.

Sump and Oil Filter (" Gipsy II " only)

This is of the wet type and can contain 20 pints of oil. A gauze screen is attached by cheese-headed screws to a ledge provided in the sump, and filters the oil, which is poured into the engine through the filler provided on the crankcase. A special tray can be fitted underneath the gauze screen if the engine should be required to run in an inverted position. In this case the tray holds the oil in the sump, and prevents the piston being flooded. The main oil pressure filter is enclosed in an aluminium-alloy casting, and this is bolted to a facing on underside of sump. This filter is accessible by undoing one large hexagon cap. Fins are provided on the underside of the sump and assist in keeping oil temperatures low when the sump is well ventilated.

Valves and Valve-operating Gear

The valves are made of steel. The inlet-valve head is of tulip form and is slightly larger in diameter than the exhaust, which has a mushroom

head. Both are operated by steel rockers through tubular duralumin push rods which have hardened steel ball and socket joints at both ends. The ball on the rocker end, which is adjustable and locked by a hexagon nut, provides for tappet adjustment. The rockers oscillate on a hardened steel spindle, which is clamped in a stamped steel bracket bolted to a lug provided on the cylinder head. Floating phosphor-bronze bushes fitted between pin and rocker minimise wear at this point.

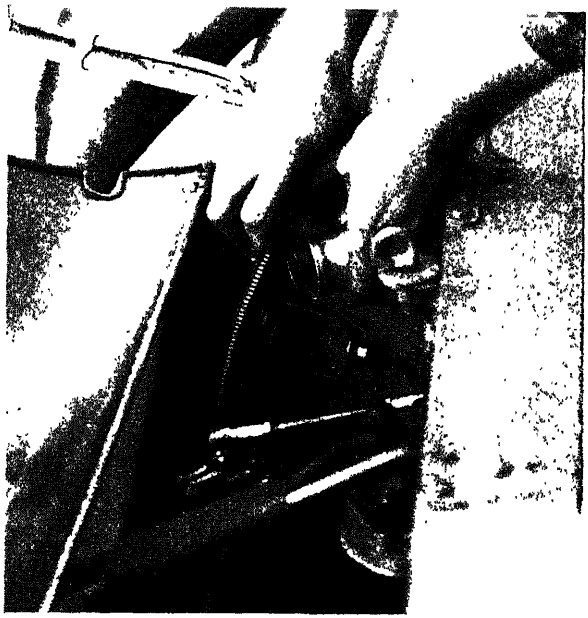

Fig. 2.—RECOMMENDED DAILY MAINTENANCE ROUTINE (2)
The fuel filter should be cleaned. The filter shown is on the bulkhead on the "Gipsy II" installation.

Fitted to the valve stems are hardened steel thimbles which, being free to turn, reduce wear to a minimum and prevent the formation of grooves where the rocker pad strikes. The rocker pads can be replaced when worn, as they are riveted in the rockers. This avoids local hardening of the rockers, with the attendant risk of fracture of this part during running.

Timing Gears

These are housed in a separate cover attached to the rear end of the engine. This cover is held on a facing provided on the crankcase and sump by studs and nuts. A spur gear fitted in the rear end of the crankshaft drives the camshaft through the medium of an idler gear. The camshaft gear is fitted with a Vernier adjustment permitting close valve timing. Bolted to an extension of the idler gear is a skew gear, meshing with a similar gear mounted on a short shaft, and through these couplings the magnetos are driven. The magnetos are bolted on sturdy brackets which are part of the rear cover.

The gear-oil pump is bolted to a facing on the lower part of this cover, and carries a spur gear which meshes with the crankshaft gear. Between

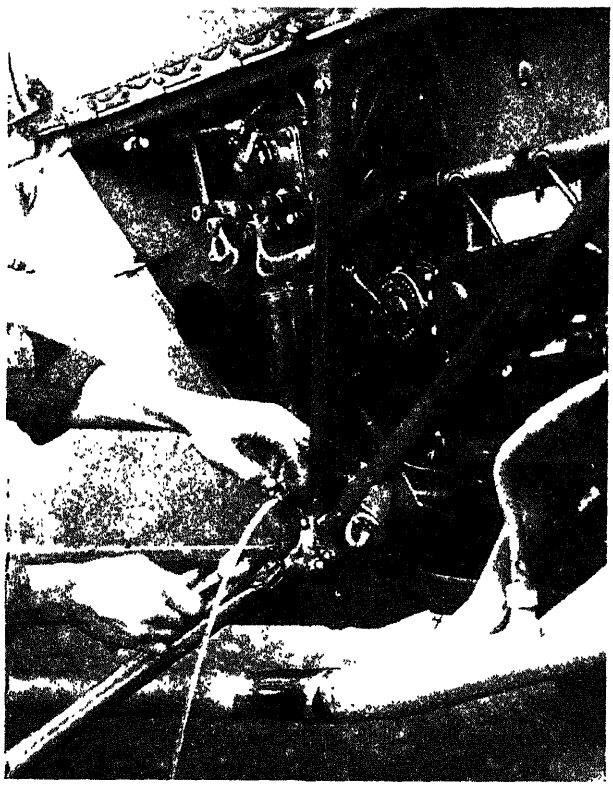

Fig. 3.—RECOMMENDED DAILY MAINTENANCE ROUTINE (3)

The pipe at the carburettor should be disconnected and fuel allowed to flow full bore. Connect pipe while flowing to avoid air locks.

the idler gear and the magneto driving gear is a small skew gear which, meshing with a similar gear, drives a single or double tachometer drive as required. One of the magnetos is fitted with an impulse starter which causes the magneto to deliver a very strong spark at low revolutions. This ensures ignition for easy starting. The contact breakers and distributors are arranged to point outwards, thus being accessible for adjustment and inspection.

Induction System

A square-section welded-steel manifold is used on both the "Gipsy II" and "III." The manifold is fitted with an exhaust-heated muff on the portion which leads from the manifold proper to the carburettor. All "Gipsy II" engines are fitted with the Hobson type A.V. 48D carburettors. The early "Gipsy III's" have the Hobson A.H. 45D and later Hobson A.I. 48.

Lubrication ("Gipsy II")

Oil is drawn from the sump by the gear pump provided on the timing-gear cover. A spring-loaded piston valve working in a bronze liner in the rear pump cover acts as a release valve, and pressure is adjusted by shims between the end of the spring and the piston. The oil is carried by pipes to the filter casing attached to the sump and from there to the main oil gallery, which is attached to connections on the port side of the crankcase. The oil is led at 40–45 lb. per square inch to the five main bearings.

Oil from Main Bearings

From the main bearings oil is forced into the hollow crankpins, which supply the big-end bearings. Holes are provided on the big-end bearing caps and bearings, from which oil is thrown on to the cylinder walls. Piston lubrication is thus effectively maintained.

Fig. 4.—RECOMMENDED DAILY MAINTENANCE ROUTINE (4)
The compression should be checked as shown.

Camshaft bearings, tappets, and cams also benefit from the oil thus thrown from the connecting rods. The surplus passes through a gauze filter tray on its return to the sump. The supply is replenished through a filler cap in the nose of the crankcase, while the quantity of oil in the sump can readily be ascertained by means of the "dipper" rod provided. A drilling in the crankcase leads oil from the rear main bearing to a recess formed in the idler-gear spindle. This is suitably drilled to release the oil midway between the two bronze bearings fitted to each end of the idler gear.

From two connections on the oil gallery, vertical feeds are taken which pass between the cylinders and are connected to a three-way fitting attached to the crankcase on the starboard side. Two pipes are run from each of these connections to the underside of the valve-gear casing of each cylinder.

The oil is then passed through a drilling provided in each rocker bracket and thence through the hollow rocker spindle to the rocker bearings. A metering plug is provided in each valve-rocker bracket to govern the amount of oil passed. The oil, after being passed from the rocker

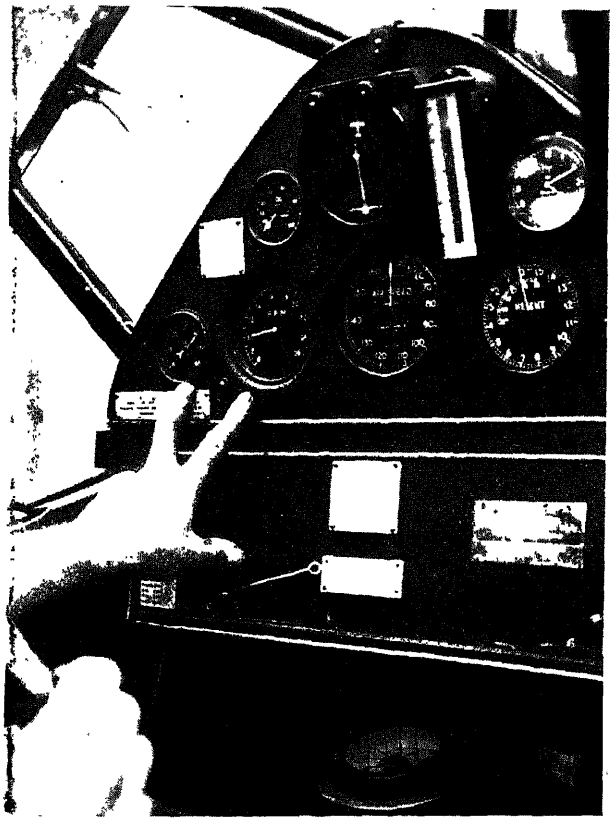

Fig. 5.—RECOMMENDED DAILY MAINTENANCE ROUTINE (5)
While the engine is running, watch the revolution counter and oil-pressure gauge.

bearings, exudes from a hole, and thence along a groove provided on the top of the rocker. This groove leads the oil to each end of the rocker and provides lubrication for the valve thimble and stem, and for the tappet-rod ball joint. The oil, which is fed to the valve gear, is caught in a pressed steel casing, which is clamped between the rocker bracket and cylinder head.

Telescopic aluminium tubes, which fit in recesses provided in the tappet guides and under the valve casing, carry the oil back to the crankcase via grooves formed in the tappet guides. A pressed steel cover fitting in a recess formed in the top edge of the valve casing catches any oil thrown off the valve gear and returns it to the valve casing. A shackle type of fixing, attached to each side of the cover, holds these in place. A Dermatine ring is fitted between casing and cover to seal the joint.

At the rear end of the oil gallery, connections are provided for two pipes, one of which supplies oil to the tachometer drive-shaft bushes and magneto gear jet, and the other for connecting up to the oil-pressure gauge.

Lubrication ("Gipsy III")

Oil is drawn from a separate tank by a gear-type pump situated on the timing cover and driven by a gear which meshes with the camshaft

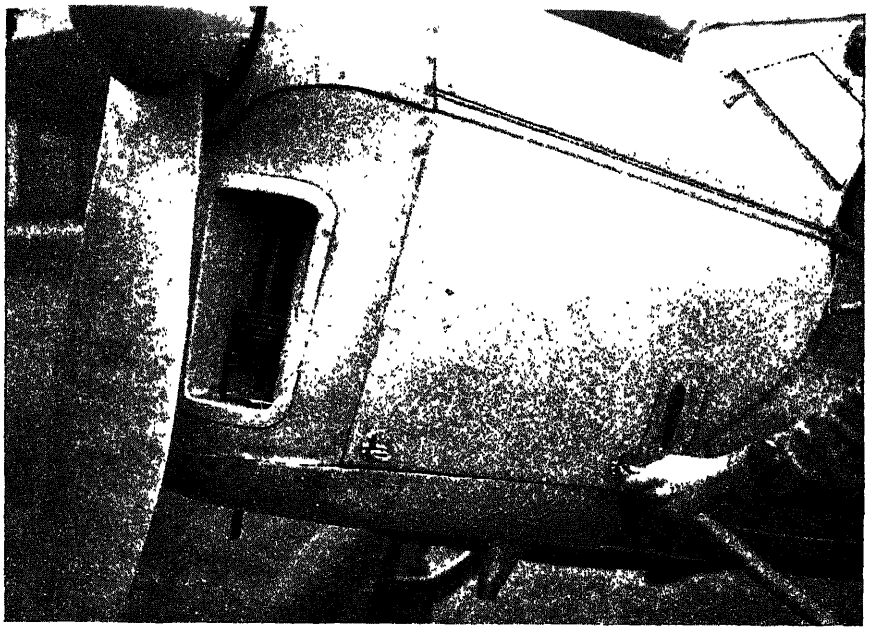

Fig. 6.—RECOMMENDED DAILY MAINTENANCE ROUTINE (6)
Check that the cowling is properly fastened.

wheel. The oil pressure is regulated to 40-45 lb. per square inch by an adjustable relief valve in the cover of the pump casing.

From the pump, the oil under pressure flows through a Tecalemit felt filter which ensures the removal of even the finest particles of foreign matter before the oil passes into the engine. This filter is positioned on the timing-gear cover, and is easily removed either for cleaning or for renewal of the element. On earlier engines the filter consisted of a fine gauze. From the filter the main supply is taken to an external gallery along the side of the crankcase and connected by drillings to the five main bearings. Thence the oil passes into the crankshaft, and so through the hollow journals and crankpins to the big ends. Holes are drilled in the big-end bearings and connecting-rod caps, from which oil is thrown on to the cylinder walls and pistons.

This arrangement is particularly useful at starting, as proper lubrication of the pistons is established during the first revolutions of the engine. Moreover, the supply of lubricant to the cylinder walls is maintained irrespective of wear and clearances in the main bearings. The spray thus created inside the crankcase serves to lubricate the camshaft bearings, cams, and tappets, and, as a good deal of it ultimately comes into contact with the walls of the top cover, a useful cooling effect is obtained.

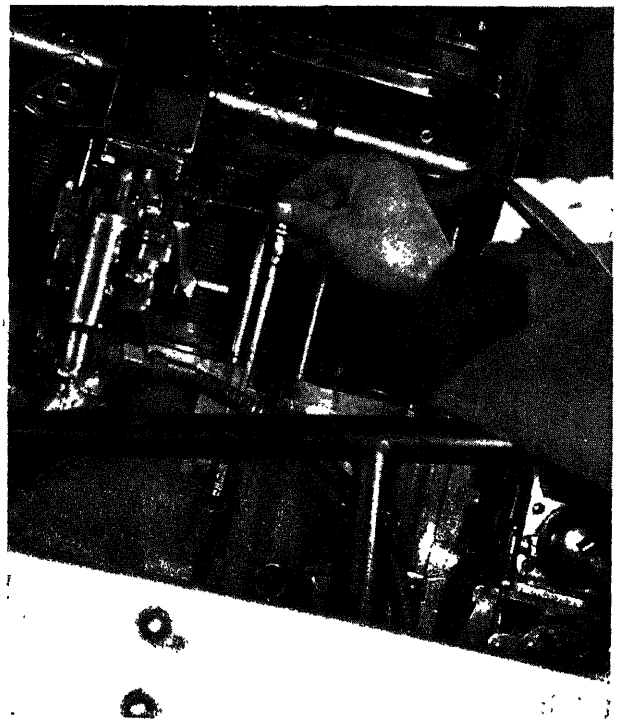

Fig. 7.—RECOMMENDED DAILY MAINTENANCE ROUTINE (7)
Check the oil level. The above illustration shows the dip stick on the " Gipsy II."

Two connections are provided at the rear end of the oil gallery, one supplying oil to the timing gears, the other for connecting up to an oil-pressure gauge. After passing through the engine, the oil collects in the space formed by the extension of the cylinders into the crankcase, whence it is returned by external pipes to the tank. Here the oil is allowed to settle and cool before being pumped back into the engine.

Oil which leaks by the tappet guides is led by the tappet-rod casings to the valve-casing cover. A Dermatine ring is fitted between the casing and cover, to seal the joint Attached to these covers is a vent pipe to release oil, gas, fumes, etc. The vent pipe carries a ring to indicate the oil-filling level when replenishing during maintenance routine. The movement of the rockers causes oil to be splashed over all the moving parts of the valve gear, and so provides for adequate lubrication.

Fuel System

A large number of " Gipsy II " and " III " engines are operating in aeroplanes with a normal gravity-feed fuel system, but fuel pumps can be provided for when required. On the very earliest engines only one face was provided on the crankcase for the cam-operated diaphragm-type A.C. Sphinx fuel pump, but later provision has been made for the Dual D.H.A.C. pumps.

The D.H.A.C. fuel pumps are also standard in the " Gipsy Major " engine when pumps are required.

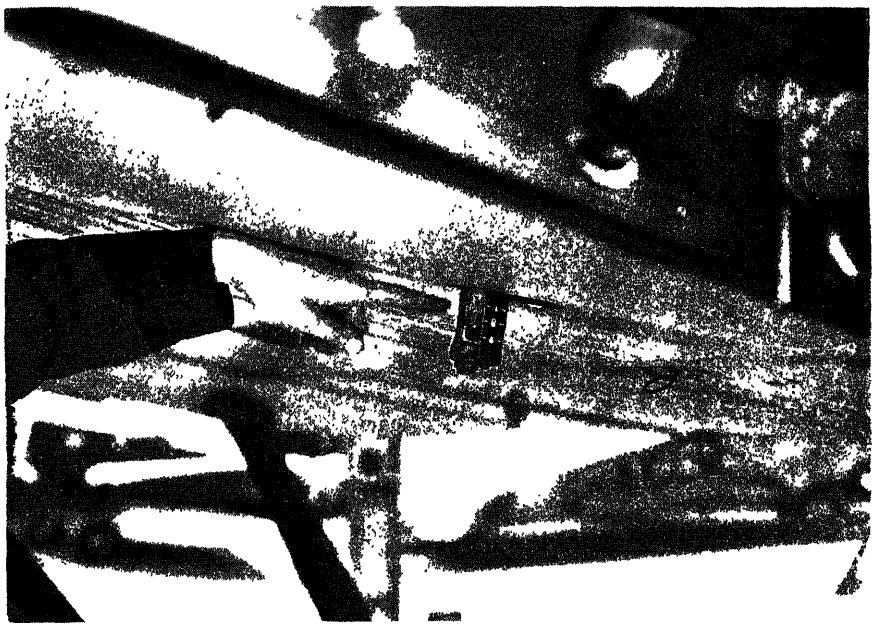

Fig. 8.—RECOMMENDED DAILY MAINTENANCE ROUTINE (8)
Check the fuel level. The illustration shows the gauge on the Puss Moth "Gipsy III."

Maintenance and Overhaul Routine

The "Gipsy II" and "III" engines are particularly easy to maintain, and the daily work will amount only to an external inspection to ensure no looseness, chafing, or displacement of parts, checking compressions, and running the engine to determine that satisfactory even running has been maintained.

After each 25 hours' flying the following routine should also be carried out:

(1) Dismantle, clean, reset points, and test sparking plugs.
(2) Clean suction and pressure oil filters.
(3) Clean fuel filter.
(4) Check magneto contact-breaker gaps and reset if necessary.
(5) Check valve clearances and reset if necessary.
(6) Before replacing valve-gear covers, add engine oil to bring up to level of ring on vent pipe.
(7) Drain oil system and fill with fresh oil.
(8) Remove and check carburettor jets and flush float chamber.
(9) Check tightness of airscrew bolts. This should be done more frequently if airscrew is new or if the aeroplane is operating in a hot climate.

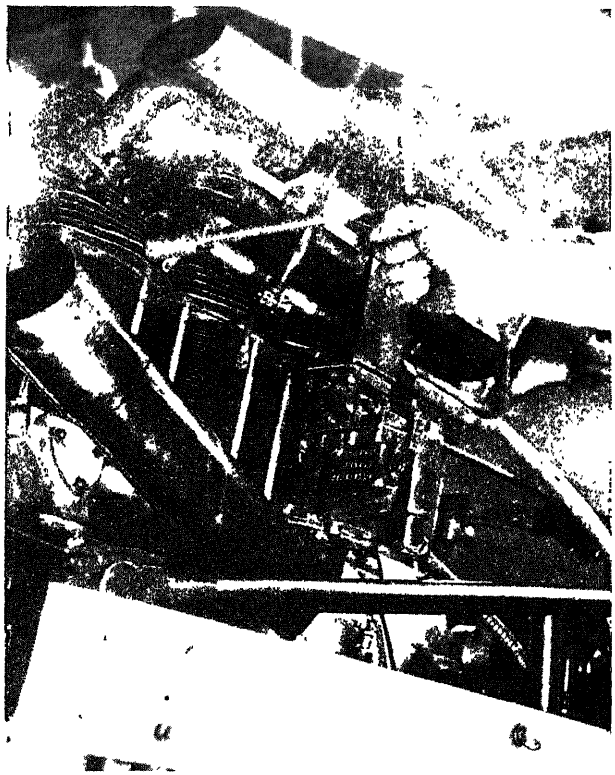

Fig. 9.—25-HOUR ROUTINE INSPECTION (1) Remove the sparking plugs ("Gipsy II").

After 50 Hours' Flying

On engines fitted with the Tecalemit oil filter a new element must be fitted.

After 150 Hours' Flying

Cylinder overhaul and decarbonising must be carried out.

Instructions for carrying out Cylinder Overhaul

This overhaul can be carried out with the engine in position in the airframe, and the sequence of operations as given below should be followed:

(1) Remove split pin, nut, and washer which holds airscrew spinner cap. Remove spinner cap, spring, and large lock plate. Nuts on airscrew bolts can then be removed, using a box spanner and tommy bar. Remove spinner retainer, front plate, and airscrew.

(2) Remove cowling.

(3) Remove carburettor-heater pipe. Use correct spanner for union nuts.

(4) Remove small nuts which hold exhaust manifold to cylinder-head flanges, using the universal spanner. Manifold can then be lifted off studs and slid out of sleeve in exhaust pipe.

(5) Unscrew fuel-pipe union on carburettor.

(6) Take out split pins in locating collars on torsion shaft of engine controls, and slide shafts to the rear out of engagement with the carburettor.

(7) Loosen clips which hold drain pipe to air-intake pipe and disconnect pipe. Remove air intake by undoing bolts which hold this to carburettor

flange. If an air-scoop is fitted it may be necessary to remove this to get air intake clear.

(8) Remove carburettor from induction pipe by undoing the four nuts which hold carburettor to induction flange.

(9) Remove small nuts which hold induction manifold to cylinder-head flanges, using the universal spanner.

(10) Remove high-tension leads from sparking plugs and unscrew sparking plugs from cylinders, using the box spanner and tommy bar.

Fig. 10.—25-HOUR ROUTINE INSPECTION (2) Dismantle and reassemble sparking plugs.

(11) Remove small bolts which hold port-side high-tension wire tubes and, leaving high-tension wires still connected to magneto, place high-tension wire tube and wires at rear of engine, so that they are out of the way of any further work to be carried out.

(12) Unscrew small screws holding valve-gear covers in place and swing stirrups clear. Remove valve cover and lift out Dermatine ring from recess in each valve casing.

(13) Depress valve collar slightly, which will depress valve and allow thimble to be lifted off. Remove all thimbles in this way.

(14) Slacken off locking nuts on ball ends of rockers, and then screw ball ends up into rockers as far as possible.

(15) Push rocker and valve hard down; tappet rod can then be withdrawn by moving it slightly to one side. Remove all tappet rods in this way.

(16) Push top part of tappet-casing tube down into lower part until clear of top cup. The tube can then be swung clear of top cup and lifted

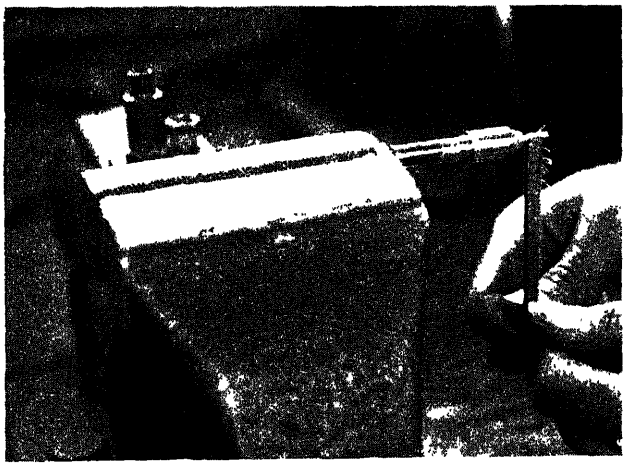

Fig. 11.—25-HOUR ROUTINE INSPECTION (3)
Clean sparking plugs. (No abrasive method must be used on mica insulation.)

out of lower cup. Remove all tappet-casing tubes in this way.

(17) Remove small bolts which hold starboard-side high-tension wire tube, and follow out same instruction as given in item 11.

(18) Loosen all cylinder-head nuts. Ease cylinder heads up as these nuts are being unscrewed, and remove all nuts, washers, and bridge plates. Should any of the cylinders show signs of sticking to cylinder heads, remove cylinder and head together, taking care to steady piston as cylinder is completely removed.

(19) In the case of the " Gipsy II " disconnect oil-feed pipes leading

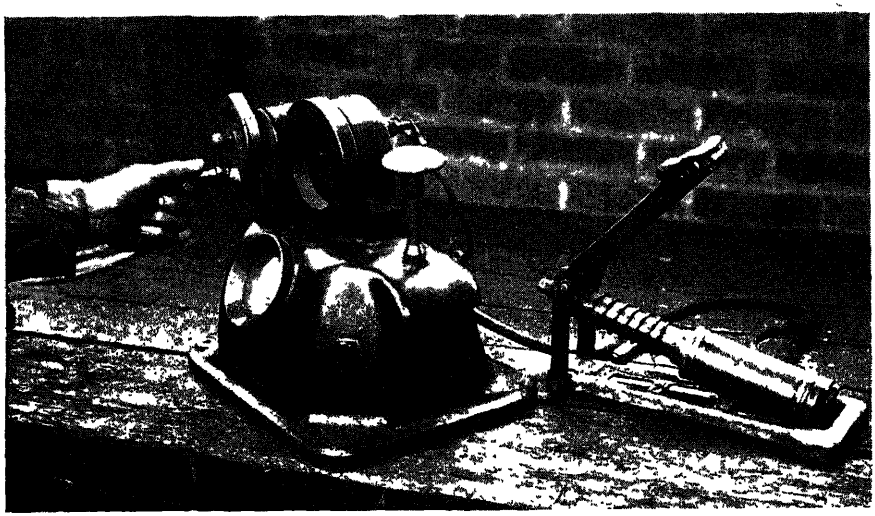

Fig. 12.—25-HOUR ROUTINE INSPECTION (4)
The sparking plugs should be pressure tested.

to valve casings. To make sure that metering plugs do not fall out, replace small plug under rocker bracket after removing pipe.

(20) With piston at end of stroke, carefully withdraw cylinders from crankcase. When cylinder is clear remove cylinder completely, steadying piston.

(21) Remove circlip from one end of each gudgeon pin, using the circlip expander and screwdriver. Insert expander in slot in end of gudgeon pin and press handles together as far as possible, which will force circlip out of groove. Insert screwdriver between circlip and washer, and a twist of the screwdriver will force circlip off end of gudgeon pin. After removal of washers, gudgeon pin can be pushed out and pistons lifted off. If gudgeon pin is too tight to be pushed out by hand, it should be extracted by using the gudgeon-pin extractor.

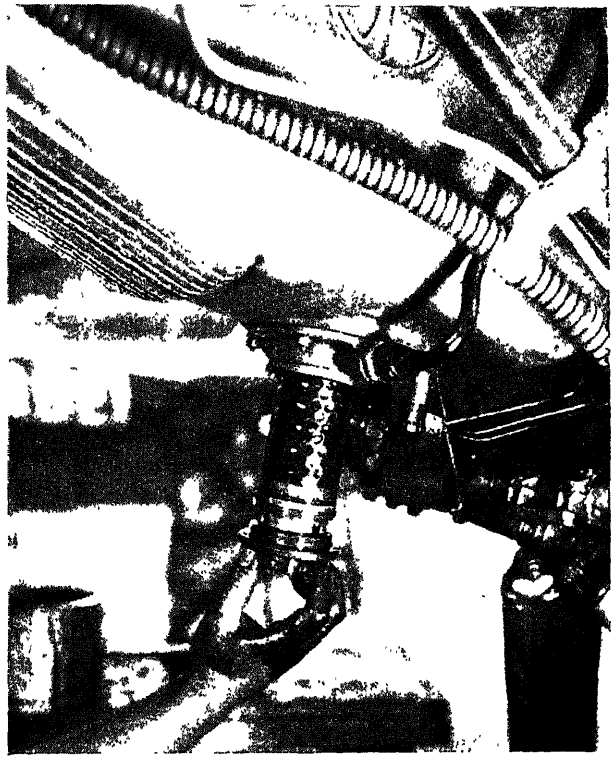

Fig. 13.—25-HOUR ROUTINE INSPECTION (5)
Clean pressure filter ("Gipsy II").

(22) Cover up holes in crankcase with rag or paper.

(23) To dismantle cylinder heads: Push collars on valve-rocker spindle as far as possible inwards, which will allow the small retaining pin in the end of rocker spindle to be withdrawn. After removal of pins, slide the retaining collars, springs, washers, and rockers off rocker spindle. Place cylinder head over a small block of wood, sufficiently thick to hold valves up in place. Depress valve collar, using the valve-spring compressor. Collets can then be removed from valve stems. Remove compressor and withdraw springs and collets. After lifting cylinder head off block, valves can be withdrawn.

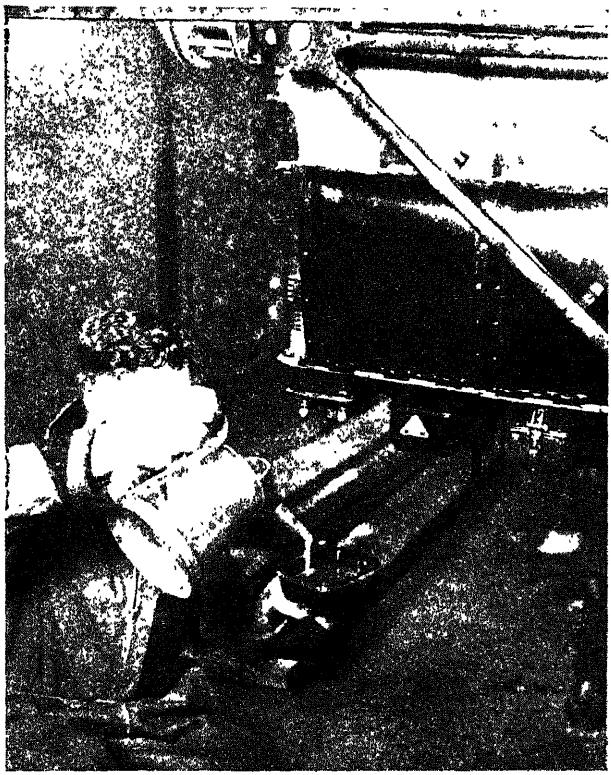

Fig. 14.—25-HOUR ROUTINE INSPECTION (6)
Top up level of oil in valve covers ("Gipsy II").

(24) To remove metering pin from under valve-rocker bracket (on "Gipsy II" engine) proceed as follows: Close up all holes on one side of rocker spindle. Join up an oil squirt to the other side of rocker spindle with length of hose. After removal of plug below metering pin the metering pin can be blown out.

(25) To remove piston rings from piston: Insert three narrow strips of thin steel under piston ring and space out equidistantly. Piston ring can then be slid up strips. Commence with top ring and slide all rings upwards, that is, towards crown of piston.

(26) To separate cylinder head and cylinder: Fix a wooden peg vertically on bench. This peg should be an easy fit in bore of cylinder. Slide cylinder down on peg, which should be long enough to reach inside of head with cylinder clear of bench. If cylinder is brought down smartly, the peg striking inside of head will generally break head loose from cylinder. If head cannot be moved by this means, heat up head in oil and try on peg again while hot.

INSPECTION

After cleaning and decarbonising all parts, the following points should be noted during an inspection of these parts:

Cylinder Heads (Aluminium Type)

Examine valve seatings for pocketing, pitting, or any signs of looseness in cylinder head. In the event of a valve seating being loose, cylinder

head should be returned to makers for reseating. If pitting or pocketing is very pronounced, a seating cutter should be used to true up seats before valves are ground in. If the seating on the valve itself is pitted or stepped, this should be ground to the correct angle before grinding with the cylinder head. Any signs of picking up or roughness on valve stems should be smoothed off and polished with superfine emery cloth. If valve guides or stems are worn beyond limits, new parts should be fitted. To remove valve guides, use special extractor. If valve guide is removed for any reason, the Hallite washer between guide and valve-gear casing should be renewed.

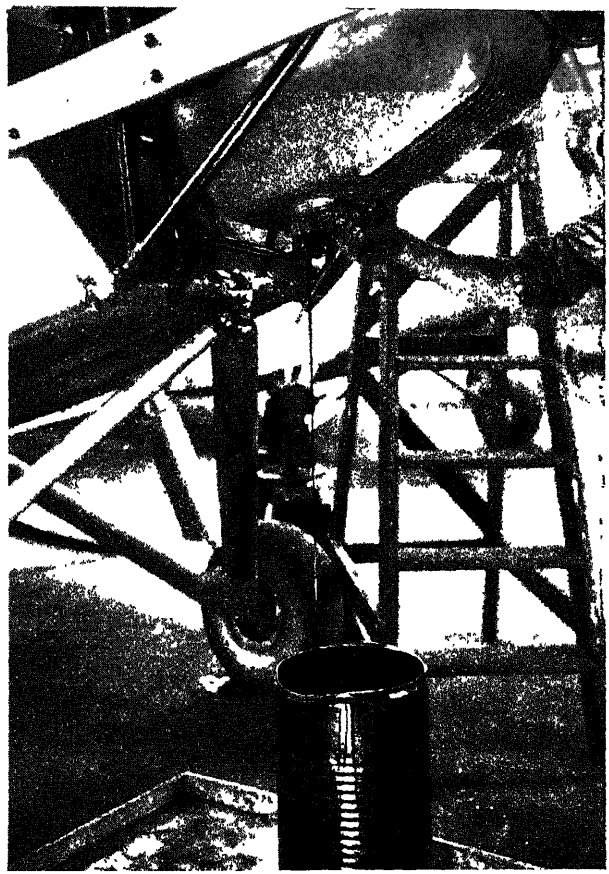

Fig. 15.—25-HOUR ROUTINE INSPECTION (7)
Drain oil from system ("Gipsy II" sump).

To avoid damaging the ends of the valve guides on replacement the soft drift provided should be used.

Bolts holding valve-rocker bracket should be checked for tightness and tightened up and repinned if at all slack. Should valve-rocker bracket be removed from cylinder head, the following points should be noted before replacement :

All joint faces should be thoroughly cleaned and a new joint made between head of cylinder and valve-gear casing and between casing and valve-rocker bracket. L'Hermetical or similar jointing material should be used for these joints.

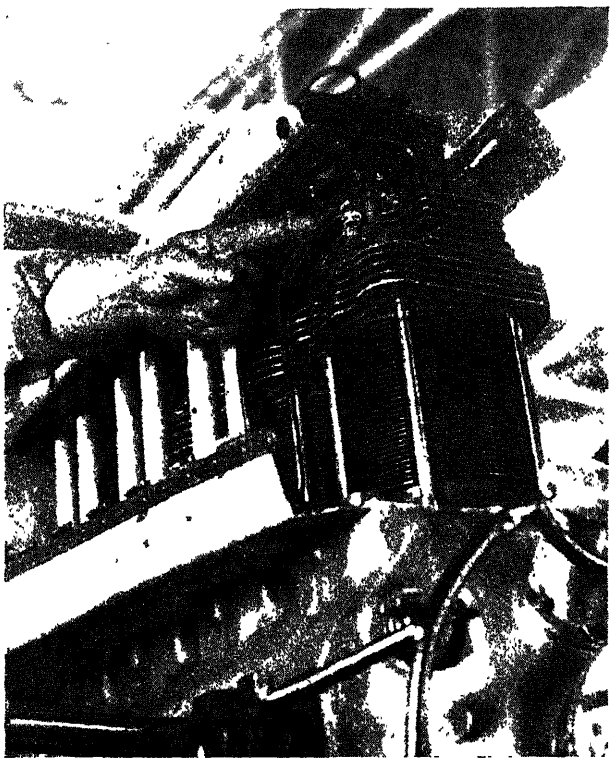

Fig. 16.—WHEN REMOVING OIL-FEED PIPES TO VALVE COVERS ("GIPSY II") MAKE SURE METERING PLUGS ARE NOT DAMAGED (See also Fig. 17.)

Check fits of rocker bush in rocker and on spindle. The minimum and maximum fit allowances will be found on the clearance chart. Check up rocker pads for wear. If wear is only slight they can be stoned smooth, but if contour of pad is badly affected a new pad should be riveted in rocker. Check up ball end in rocker and socket on tappet rod for any signs of pitting or undue wear. If pitted, however slightly, renew. Should cylinder head have been at all difficult to slide up cylinder-holding studs when engine was being dismantled, the holes in head which take these studs should be checked. These holes sometimes close in slightly at the top end and should be eased out to the original diameter.

The cylinder head should be checked for distortion, as follows :

The cylinder head should be placed on a surface plate and distortion should be checked by inserting feelers between face on cylinder head and surface plate. All burrs, etc., should be removed from face of cylinder head before carrying out this operation. Feelers should be inserted at points midway between cylinder holding-down stud bosses. The head should be held down tightly to surface plate while carrying out this operation, and should be checked between all four bolt bosses.

The maximum distortion allowable measured in this manner is 0·025 in., and any head showing more than this should be scrapped. Heads showing between 0·010 and 0·025 in. can be used, provided the seating for the copper and asbestos washer is trued up. This seating can be trued

up by skimming in a lathe, or it can be lapped. using an old cylinder as a lap. Heads showing less than 0·010 in. can be considered serviceable without any rectification.

Important. — In no case should more than 0·012 in. of metal be removed from seating for truing-up purposes.

The rocker-bracket bolts (aluminium heads only) should be inspected in accordance with Ground Engineers' Notice No. 40 of 1931.

The valve-rocker platforms (aluminium heads only) should be inspected according to Ground Engineers' Notice No. 32 of 1932.

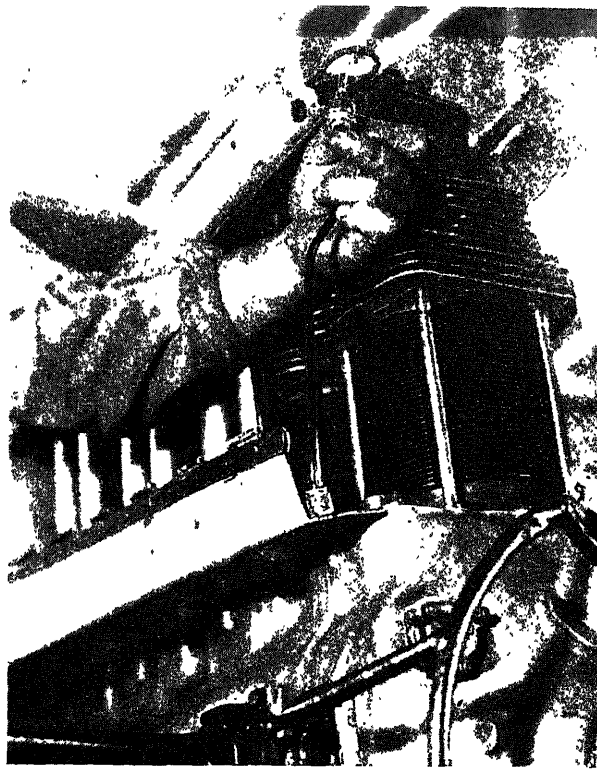

Fig. 17.—ON LATER ENGINES THE METERING PLUG IS ATTACHED TO THE ADAPTOR, BUT ON EARLY ENGINES IT WAS A SEPARATE PART

Cylinder Heads (Aluminium-bronze Type)

The instructions concerning the aluminium type are generally applicable, except with regard to the valve seatings. In the aluminium-bronze type the seatings are formed directly in the material of the head, and the permissible amount of cuttering of the seatings is shown on the manufacturers' drawing.

Pistons

These should be checked for cracks, wear in gudgeon-pin bores, wear in ring grooves, and wear on diameter. Minimum and maximum dimensions are given on the clearance chart. Piston rings should be checked for blowing by loss of spring or excessive gap. If piston is inserted in the cylinder, the crown can be used for squaring up rings when checking gap. Fit piston ring to piston for checking ring-groove

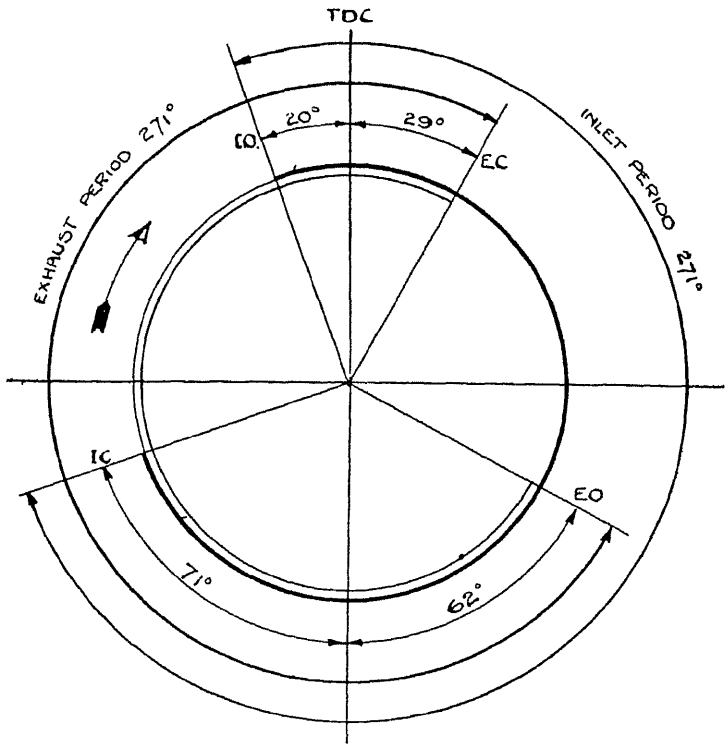

Fig. 18.—VALVE-TIMING DIAGRAM (CRANKSHAFT COLD)

clearance. Before doing this make sure that the ring grooves are free from carbon.

See notes under " Cylinders " *re* oversize replacements.

If on dismantling early engines, pistons Part Nos. 800–15A or C are found, opportunity should be taken during top overhaul to modify them as follows : The skirt of the piston should be shortened to make the piston an overall length of 70 mm., measured from the crown. The excess of metal can be removed by hand tools or turned off. The corner of the skirt should then be given a 5-mm. radius, and any sharp corners where cross-webs join the skirt should be carefully radiused out. Any piston weighing less than 24 oz. 7 drams after shortening must be replaced.

Check up for wear and cracks. Check fit in connecting rod against sizes given in clearance chart.

If on dismantling very early engines, gudgeon pins Part No. 1300/17, gudgeon-pin washers 1300/18, and circlips 1300/19, are found, they should be replaced by :

Gudgeon pins, 800/17. Gudgeon-pin washers, 800/18. Gudgeon-pin circlips, 800/19.

The old-type gudgeon pin can be easily identified, as it is reduced in diameter at the ends to receive washer and circlip. The new type is the same diameter throughout.

Check up for wear, ovalness, or scoring in bores.

The manufacturers have repair schemes whereby cylinders can be ground 0·005 in. oversize, and provide special piston rings to be used with the standard-size piston. Also there is a scheme for grinding 0·010 in. oversize and the fitting of special oversize piston and rings.

If the connecting rods are of the Y-alloy type and have embossed lettering on the web portion of the H-section, they should be inspected in accordance with Ground Engineers' Notice No. 29 of 1933.

Reassembly

The following parts should be replaced by new :

Dermatine ring under cylinder base. Copper and asbestos washer between cylinder head and cylinder. Hallite washers on induction ports. Copper and asbestos washers on exhaust ports. Dermatine ring in valve-gear casing. Joint rings at top and bottom of tappet-casing tubes. Hallite washers between carburettor and induction manifold.

The following points should be noted during assembly :

(1) All parts should be freely oiled during assembly.

(2) Scraper ring should be nearest the gudgeon pin and the land of the ring towards the crown of the piston.

(3) On the "Gipsy II," before metering pin is replaced in valve-rocker bracket the bore which takes this pin should be cleared of all jointing material, and pin should be a free fit when in place. This pin should be fitted before heads are replaced on engine, and should be held by screwing plug in temporarily until oil pipes are fitted.

(4) When reassembling cylinder heads, use the valve-spring compressor to hold collars down while replacing collets.

(5) Before reassembling any parts on crankcase, this should be thoroughly cleaned. Remove drain plug under sump and allow all dirty oil to drain out. Remove pressure oil filter and casing from sump. Clean crankcase externally with petrol. Clean pressure and suction filters and casing.

(6) Pistons for the "Gipsy II" and "III" were originally selected into three weights and marked by the affix "X," "Y," or "Z" to the part number. Tests have proved that this selection is unnecessary to the smooth running of the engine, and the various weights can be mixed in the same engine if required.

(7) When refitting circlip on gudgeon pins, use the circlip expander. Circlips when fitted must be a tight fit in groove in gudgeon pin. If at all loose they must be renewed.

(8) Piston-ring gaps should be spaced equidistantly before fitting to cylinders. When replacing cylinders, use the piston-ring clamp to hold piston rings in place. As cylinder is pushed down, the clamp will be pushed off piston and can be withdrawn before cylinder is right down.

(9) While cylinder heads are being put down, make sure that bridge pieces, thin and thick washers, and nuts are put in place. Cylinder nuts should be screwed down just sufficiently to hold heads, and the heads should be lined up by a straight edge against the inlet-port facings. The cylinder heads should then be tightened down by tightening nuts on opposite corners alternately. The nuts, finally, should be screwed down firmly and evenly.

(10) When replacing valve-gear covers the stirrup screws should be tightened down just sufficiently to make an oiltight joint between cover and casing. Do not strain cover by tightening screws unnecessarily.

(11) Nuts on inlet and exhaust manifold should be tightened up progressively. Do not strain unnecessarily when tightening.

(12) When replacing airscrew the following points should be noted :

The nuts on airscrew bolts should be tightened up alternately on opposite bolts. The amount of thread should be checked to ascertain that the nuts are not bottoming on end of thread before airscrew is tight.

When assembly is complete, the engine should be filled with clean oil and run at about 800 r.p.m. for about 15 minutes to allow oil to circulate before being opened up to full throttle.

After 450 Hours' Flying

The engine should be removed from the airframe and given a complete overhaul.

Note.—" Gipsy III " engines subsequent to No. 3488, or engines which have been completely overhauled by the makers, modified, and brought up to date, can have this running period extended to 500 hours.

Magnetos, carburettor (and fuel pumps if fitted) should also be overhauled.

Magneto Timing

Note.—In order to provide for the use of fuels with a low H.U.C.R. (highest useful compression ratio) figure coupled with low r.p.m. at full throttle on the climb, it is considered advisable to reduce the magneto timing of the engine.

The original advance was 40° *before top dead centre.*

This should be reduced to 34° *before top dead centre.*

This new advance position should be marked on the front cover and magnetos should be retimed to this at the first opportunity. The front cover should be remarked for magneto advance at a point 38 mm. before top dead centre measured round the periphery, and the existing magneto advance marked approximately 44·5 mm. should be filed out. The engine number plate should be altered accordingly.

ENGINES

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